THE

CAUSE AND PREVENTIVE

OF

STEAM BOILER EXPLOSIONS,

PART I.

CONTAINING A SHORT HISTORY OF EXPLOSIONS,

WITH COMMENTS.

PART II.

CONTAINING THE CAUSE AND PREVENTIVE,

WITH

SOME OF THE AUTHORS EXPERIMENTS,

TO WHICH IS ADDED

A DESCRIPTION OF A VERY IMPORTANT INVENTION RELATING TO ALL IRON HEAT DEFUSING DEVICES, OR APPARATUSES; TO PREVENT THE GENERATION OF THE UNHEALTHY ATMOSPHERE, WHICH IS RADIATED FROM ALL IRON HEATED SURFACES, NOW IN USE, SUCH AS STOVES, FURNACES &c.

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DAYTON, O.

GAZETTE COMPANY, PRINT.

PREFACE.

In presenting the following little work to the public, the writer is well aware that it will meet with much opposition, as it is well known that it is a prevailing belief, (especially with scientific men,) that steam boiler explosions are only the results of the ignorance, incompetency, and negligence of those entrusted with steam machinery; which is wholy at variance with the views, arguments, and experiments presented in the following pages. All that is solicited, (of those that have any concern with steam machinery,) is, to give both sides of the subject a fair and thorough investigation; not only theoretically, but, practically. This mode of testing all things, ideas, and theories whether old or new, is the only true method. Any theory that will not stand a practical investigation is not true, and should be abandoned by every intelligent being. It is very improper and highly pernicious to propagate popular theories old or new, that will not hold true in practice; not only that in many instances it causes the destruction of many lives, and much property, but, it has the tyranical tendency to deter many men from investigating in opposition to such popular theories, thereby retarding that advancement and progression, which is so necessary for the welfare and happiness of mankind.

The elements connected with steam machinery are very dangerous, and under certain conditions become ungovernable; and have heretofore been entirely beyond the control of the most judicious engineers.

I do not wish it to be understood in this connection however, that I consider a legitimate regulation with regard to steam navigation as useless. There are other perils attending navigation besides "explosions;" such may be within the control of the moral and judicious discipline of navigators.

The subject under consideration is strictly, that, relating to steam

boiler explosions—which is intended for the investigation, and use of practical men.

Having first ascertained by mathematical computation, that simple steam pressure expansion, is inadequate to violently explode steam boilers, and project fragments to great distances, a series of experiments were made to ascertain the true cause, and if possible its preventive. These experiments have proven that the above named calculations were correct. And after the close of these experiments—the history of steam boiler explosions was collected as far as it could be obtained; which proved to harmonize with the experiments, as well as to prove that the expansive force of simple steam, has nothing to do with it, as the sequel will show.

An extract of the history of steam boiler explosions, is placed foremost in the following pages, as it is thought to be most proper to lay before the reader first.

The arguments in the following pages will be condensed as much as possible, to avoid prolixity, and prevent their being extended beyond intended limits.

Dayton, Ohio, March, 1855.

PART I.

Nature in her infinite laboratory, presents an infinite variety of phenomena, which are the results of analysis and synthesis. In the former case separation presents the original quality of principle and material; while in the latter case combination presents the new, or combined quality of original principles, and materials. Under those two heads there is an infinite variety of changes produced in nature. Man must study nature if he wishes to become acquainted with her laws; which are as numerous as there are combinations of materials. Every new combination presents a law peculiar and adapted to its combination only — and every further combination of materials presents a law corresponding to such combination. Analysis of materials, or elements serve as causes which produce results corresponding to the isolated state of such elements. So with combination, every addition of element, produces a new result corresponding to such new compound.

The true philosopher can find his way step by step through the great complication of nature by investigating from cause to effect, and from effect to cause — which may be arrived at by analyzing and combining the principles, and elements of nature. Apparently the minutest addition, or abstraction of elements, or materials often are productive of the most unlooked for consequences — although such results are the legitimate effects of their preceeding causes — and could have been foreseen by the mind of the philosopher, if, he had been properly familiar with the laws producing such results.

Under this head the subject of steam boiler explosions will claim our special attention. Ever since the first discovery of the use of steam, the practical engineers as well as the scientific men, have devoted much time and labor to ascertain the cause of explosions, in order,

to apply its proper preventive—hitherto however, experience has taught, that the whole subject has been involved in much doubt and mystery—for explosions the most violent have occurred notwithstanding, all that has been done to prevent such consequences—and too with men who were most cautious,* which is evidence that the true cause and the legitimate remedy has hitherto been unknown. Explosions have occurred in many instances in which "committees," who undertook to ascertain the cause, (have been unable to find a cause adequate to produce such terrific effects,) have uniformerly returned their verdict attributing the cause to agents and circumstances entirely inadequate to produce such terrible wreck—such as defective metal—overheated metal—and excessive steam pressure, etc. etc.,—neither of these however will be a philosophical answer, as will be shown hereafter.

The true philosophy of investigating any subject is first to search in nature for a true-reliable foundation—and before this is done, it is of vital importance to ascertain whether we may not set out with our mind swayed with preconceived ideas or other prejudice, or opinion upon the subject which we are about to investigate. If such be the case we will very likely build upon false theories instead of the true foundation which exists in nature—and which can only hold true in practice. Man is liable to be deceived in apparently the most simple things that he is surrounded with. He may think, being, connected for a long time, with certain subjects, and being compelled from certain circumstances to form certain opinions respecting thereto, which opinions recur to his mind again and again, that such must undoubtedly be correct; while at the same time they have no existence in nature, and will not hold true in practice. If opinions, and theories are to be relied on, they must hold true in physical analogy; every circumstance connected therewith must tend to confirm the correctness thereof. All things, circumstances, and connections in the true science of nature must harmonize so as to tend to develop the one general result; otherwise it is not a fact in physical analogy. However, conversant a man may be, in what is termed sciences combined with theory; he is liable to draw very erroneous conclusions—from the fact that the knowledge that he has obtained of sciences, is principally, if not wholy obtained from scientific books; which usually contain a large portion of that which should legitimately be termed theory. Science, or more properly speaking, nature, is one continuous, and corresponding development. Such is the character of natures laws. If

*The Anglo Norman.

one, two or more causes are uniting, we must according to natural law, look for an effect corresponding to such cause or causes—that is the effect must not exceed in character, what the cause or causes are unable to produce — otherwise our looked-for will be founded upon a fabulous theory. For instance, if, in a steam boiler the pressure is less than the strength of the plates, then an explosion can not take place, if it does, then we must look for some other agent besides simple steam. Or if we find by a law in nature, that when the steam pressure within a boiler, if raised beyond the strength of the boiler plates, ruptures only would ensue, according to the elastic or expansive property of steam, and if this natural result does not ensue, but instead thereof, a violent explosion follows, that projects large pieces of the fractured boiler to greater distances, than the simple expansive force of steam could produce; then we must look for a cause much more powerful than simple steam, one that corresponds to the result. To attribute such terrific effects to causes that could not in their nature produce such effects, involves an absurdity in the nature of things—and aims the fatal blow at the harmony of nature. It is better, however, that man as an erroneous theorist, rather than natures laws should be found clashing. Nature is ever correct and consistent in all her developments. The error is only in man's mis-comprehension of her laws; therefore he is often mistaken, in attributing effects to causes that would imply a contradiction in the correspondence of cause and effect. Man is apt to form hasty conclusions, because he sees and reasons improperly, or from appearances—without being able to take a comprehensive view of the entire subject. From hasty conclusions many errors have been introduced into the world, and through prejudice have been propagated from time to time. This has been a great obstacle to the introduction and propagation of true and useful knowledge. There are, however, many men who reason and draw their conclusions from correct premises. From such, the world has in all ages reaped a ripe and bountiful harvest.

With these preliminary remarks, which it will be well for the reader to bear in mind, I will proceed with the investigation of steam boiler explosions.

The causes of steam boiler explosions as laid down by "scientific" committees—and civil engineers, may be classed under the following heads:

1. Excessive pressure within a boiler, the pressure being gradually increased until it becomes too great for the strength of the boiler, which results in a violent explosion.

2. The presence of unduly heated metal within a boiler; this unduly heated metal is said to be the result of different causes, such as deficiency of water; and of incrustation, and from careening of the boat, when the water in the higher boiler of course will descend to the lower, thereby exposing the metal to the action of the fire.

3. Defects in the construction of a boiler or its appendages—such as defective material either in quality or thickness—defective construction in form—and defective workmanship.

4. The carelessness, or ignorance of those entrusted with the management of the steam engine. To this last named causality, (according to the theory,) may be attributed all the explosions that ever occurred. For it is either ignorance or carelessness, to allow excessive pressure within a boiler; or to allow the presence of unduly heated metal within a boiler, either from deficiency of water, or otherwise; or to make, or use defective boilers, either in form, or material. If, as they say, that all explosions are the result of the foregoing causes, then they all result from the last supposed cause, ignorance or carelessness.

It will be seen by a careful perusal of these pages, that the above named theory of causes, has but little connection with the real cause of steam boiler explosions.

These supposed causes as above laid down, will be discussed in their proper places, to which certain cases of explosions are attributed.

COLLAPSING OF FLUES.

* * * * From an eye witness: In the case of the B. J. Gilman—"That she colapsed a flue with an ordinary head of " steam, and with water in her boilers so far over the flues, that after " the explosion took place, it still covered the flues. The iron was the " thinest he ever saw used for such purposes. The Persian, Oronoco, " Missouri, Alton, Majestic, and various others, also, collapsed on ac- " count of insufficiency of strength in the iron of the flues. In all " these cases there appeared no deficiency of water in the boilers. A " remarkable proof of the importance of suitable thickness to the flues " was afforded in the case of the Steamboat Cutter. The boat had " careened over, owing to the passengers getting to one side. At this " moment the flue on the lower side, which proved on examination " afterwards, the thinest, collapsed, although submerged in water, while " the upper flue, which was unduly heated, did not explode."‡ * *

It appears from the above, that flues do collapse, while covered with water, and with an ordinary pressure of steam. And in one case in which the boat careened thereby submerging one flue in water, which collapsed, while the other being the thickest, was laid bare, and became

‡Report of the Commissioners of Patents, to the U. S. Senate.

unduly heated, yet bore the same pressure of steam. This shows that the above mentioned flue did not collapse with steam pressure—as a flue unduly heated will give way at less than one fourth the pressure that it requires to collapse one submerged in water. If the collapsed flue were the thinest, it yet follows that the unduly heated one would have yielded first, unless it were four times the strength of the submerged one, which is not likely to have been the case. A proper investigation of the laws that give strength to cylinder forms, will show that it requires a much greater pressure than is usually used in steam boilers, to crush a flue submerged in water, as the pressure is centripetal, and therefore acting equally all around. To collapse a cylinder flue with a pressure applied equally all around, which must be of such pressure as to cause the metalic fibers to yield or crush, requires a much greater pressure than most steam boiler shells will bear.

It is evident from the form and metalic structure of flues, that they do not collapse by a gradual steam pressure, but by explosive percussion. This part of the subject will be treated under its proper head.

From the Committee of the Franklin Institute, vol. 22, page 431.

REPORT ON THE EXPLOSION OF A STEAM BOILER AT MORRIS & CO'S. FACTORY.

(*Explosion No.* 1.)

"That the boiler in question was of a cylindrical form, 5 feet in diameter and 16 feet long, having a fire-box at one end, from which three main flues, the largest of which was 20 inches in diameter, extending to the smoke-box, from which twelve return flues, 6 inches in diameter, carried the products of combustion to the chimney. Near the end of the boiler there was a steam dome 4 feet in diameter which was placed over an opening of the same size in the shell of the boiler. The iron of which the boiler was made, was of the best quality, 0.3 inches in thickness. This boiler was intended for the use of a Steamboat, and was to be used under 100 lbs. pressure. The parties who ordered it, required it should first be tested under a pressure of 150 lbs. Upon this trial the fire was kept up, until the safety valve lifted under a pressure of 148 lbs; an additional weight was then added sufficient to give the requisite pressure of 150 lbs. and after a few moments, the experiment was considered as satisfactory, and directions were given to open the fire-doors; at this moment the explosion took place, killing one of the persons present, and severely injuring two others, one of whom has since died. The boiler was torn into at least three pieces, by fractures perpendicular to the axis,—one of which (the fire box end) was thrown forward and came in contact, with two large Cornish boilers which were lying in front of it, indicating by its effect upon them, the terrific violence with which it had been projected. The waist of the boiler was torn from the steam dome, ripped open, and flattened out upon the wharf where it lay, while the steam dome and other portions, were thrown high into the air, and fell into the Delaware

river, whence they have not been recovered. The main flue was also separated from the rest and thrown into the dock, whence it was afterwards recovered and found flattened, but apparently not collapsed by the pressure of the steam.

In seeking to account for this explosion, we may in the first place remark, that there appears no reason whatever, to suspect the existence of a low water-level. The experiment had been but a short time in progress, no water or steam had been lost, except that which was blown off at the safty-valve, nor was any pump in connection with the boiler by which cold water might be thrown upon an exposed and overheated surface. This, then, the most common of all causes of explosion of steam boilers, cannot be reverted to, to explain this one. Nor is there any reason to suspect carelessness or recklessness on the part of those in charge of the experiment, nor negligence or mistake in the calculation of the pressure on the safty-valve. The boiler was at the time under the charge of perfectly competent persons, who were under no excitement, had no inducement to rashness, ner were under the circumstances, likely to lead to over haste, and whose lives were, as the result too sadly proved, exposed in the event of an explosion. The Committee submitted to the proof of the breaking apparatus, pieces of the iron taken from the edges of the fractures, and the results showed that the iron was of good quality. The following are the breaking weights per square inch of section, of the pieces :

Iron taken from the side of the boiler;	with fiber,	67.200 lbs.	across fiber,	67.200 lbs
" " " Shell,	"	" 50.400	" "	" 56.000 "
" " " Flues,	"	" 53.760	" "	" 54.880 "

If from these data, and the diameter and thickness of the shell of the boiler, we calculate its strength, and compare it with the effort exerted upon the shell by a pressure of 150 lbs. per square inch, we shall find after making all possible allowances, a simple cylindrical shell of such diameter and thickness, and made of such materials, would have been fully equal to the strain brought upon it. But when we consider the effect of the large opening made into the steam dome, we shall see that the strength of the cylinder was very materially diminished, and probably brought below what was necessary to resist the strain upon it.

It will be easily seen that the effect of such an opening thus covered, must be to bring a greatly increased strain upon its edge, where it intersects the upper line of the shell, while the dome itself gives but little aid in resisting this pressure, and if the deformation of the shape or a tear of the iron should be the consequence, the other results of the explosion might easily follow. The committee deem this defect of form to be so manifestly sufficient to account for the explosion, that they do not think it necessary to advert to any other, but strongly call the attention of boiler builders and engineers to the importance of avoiding such large openings in the shell, in the future.

In conclusion, they take this opportunity of returning their thanks to J. P. Morris & Co., for the facilities which they so freely offered them for a thorough examination.

By order of the Committee,

W. HAMILTON,

Philadelphia, Nov. 13, 1851. Actuary.

The above case is given in detail, because it is thought that it is a good specimen, for several reasons. First, it appears from the above extract that a scientific committee obtained the privilege of a thorough examination, while those concerned with the boiler could have had no object to misrepresent or conceal any thing from the committee. Second, the case was different from nearly all other explosions on record, because the boiler was set up for trial, without having an engine attached to it, to exhaust steam, to cause commotion in the boiler, and supply water to come in contact with over heated metal; while at the same time there was no careening motion, such as is the case with the river boilers; no reckless and incompetent engineers at hand; no racing; no inferior iron; no bad workmanship; no shallow water lines; no adhesion of safety-valve; no giving away of stays; no extraordinary pressure of steam; no priming to cause convulsion within to throw the water against unduly heated metal; nothing of the kind is reported. And this dissolves (with one exception,) the whole catalogue of supposed causes incident to steam boiler explosions. The committee have however, reported upon the exception above stated, which falls under the head of deficient or improper construction. The opening of four feet in diameter, which was made on the top of the boiler to fasten on a steam dome, the "committee" seem to think was the cause of the explosion. Such however, does not seem to be the cause, from the evidence of the lines of fractures; the projection of the pieces, in connection with the expansive force, of that volume of simple steam at 150 lbs. per square inch pressure. We have not been shown upon what principle of philosophy, or mathematical proportion, a circular opening on the top of a boiler, (in diameter a fraction over a fourth the circumference of the boiler,) and fitted in with a dome of proper strength and proportion, should diminish the strength thereof more than one half. It is ascertained from the data above, taking the lowest figure, 50.400 lbs. and making all reasonable allowance for riveting, &c., that this boiler should have borne at least 340 lbs. per square inch pressure, without rupture, instead of violently exploding at 150 lbs. per square inch.

It should be recollected, that this dome opening was made at one end of the boiler; and if it was the cause of diminishing the strength of that end of the boiler, from 340 lbs. to 150 lbs. pressure to the inch, it surely did not diminish any other portion of the boiler, further than the dome was extended. Suppose, for example, the dome opening had diminished that portion of the boiler to one half its former strength, and steam would be permitted to be generated in

it, until rupture would ensue, what kind of fracture would follow such a state of things? From the laws that govern this part of material nature, it is evident that the part which is the weakest would give way, so the fracture from excessive pressure would separate the end with the steam dome from the main body of the boiler, perpendicular to the axis, or it would rent on top from the center of the steam dome on a line with the axis. From the committees report it appears that such a result did not follow, but a violent explosion by which the boiler was torn into at least three pieces by fractures perpendicular to the axis, one of which was near the front end, and must have been at that part of the boiler end that should have borne 340 lbs. pressure, instead of 150 lbs. The waist of the boiler was torn from the steam dome, ripped open and flattened out upon the wharf. This seems clear that simple steam, at 150 lbs. pressure per square inch, did not do such terrible work. Again the expansion of such a volume of simple steam in a boiler of the foregoing dimension with a pressure of 150 lbs. to the square inch would only extend to an area of about 12 feet in diameter and 16 feet in length when it would be at equilibrium with the atmosphere.* Could such limited expansive force have projected heavy pieces of metal high in the air and onward into the Delaware river? In this case we have the gathering and combining of explosive elements taking place, without a working engine to work off the steam which became impregnated with such elements. It is the most dangerous, to generate steam in a boiler without an operating engine to work it off.

(*Explosion No. 2.*)

The "Irk" locomotive, which blew up in 1845,‡ was another of those results, of which simple steam even at a very high pressure, could not have been the cause. In this case it is reported, that it is supposed that the top of the copper fire box was forced down upon the blazing embers of the furnace, which acting upon the principle of the rocket, elevated the boiler and engine of 20 tuns weight, to a height of 30 feet, which, in its ascent, made a summerset in the air, passed through the roof of the shed under which it stood, and ultimately landed at a distance of 60 yards from its original position. In this case it is supposed that the pressure may have ranged between 200 and 300 lbs. per square inch, not known however, as it was ascertained that the safety-valve was fastened down. Let this be as it may; no boiler made for locomotive purposes, could have generated within its shell

*See calculation on steam expansion, further on,
‡From the London Artizan, for June 1851.

simple steam of sufficient elasticity though it be 1000 or 1200 lbs. per square inch, to project in the event of bursting, a locomotive of 20 tons, 30 feet into the air, with a summerset and landing it 60 yards from its ascent. Nothing short of the most terrific explosive elements in nature, can be the agent of such results.

From the Pittsburgh Gazette.

EXPLOSION OF A LOCOMOTIVE—ENGINEER KILLED AND SEVERAL PERSONS SERIOUSLY INJURED.

"An explosion of a locomotive occurred on Wednesday morning about a quarter before 8 o'clock, on the Cleveland and Pittsburgh Railroad, which resulted in the death of the engineer and the serious injury of several other persons employed on the train. The particulars are as follows:

The wood train of the C. & P. R. R., was standing on the track about one mile south of Alliance, the hands being engaged in loading the cars with wood, when the boiler of the locomotive—the "Portage"—exploded. Both ends of the boiler were blown out and the engine and boiler were shivered to atoms, leaving the machine a complete wreck. The tender was also destroyed and the wood scattered in every direction from the track.

The engineer, David Parker, who was on the locomotive at the time, was instantly killed. He was thrown between two and three hundred feet. His body was scalded and mangled in a terrible manner. Pieces of his clothing were found on the branches of trees standing near by, and his watch was carried a distance of an hundred feet beyond the body of the deceased. Mr. Parker was a resident of Ravenna, and was without family.

The conductor of the train, Mr. Anderson, was struck on the head by a flying fragment of the engine, his skull broken and mashed so that the brains protruded; his body was otherwise injured. There is no likelihood of his recovery. He is now lying at Alliance under medical treatment, but he himself says he has no hopes of life. His skull was trepanned in the afternoon.

One of the men employed on the train had three ribs broken by a piece of the machinery, and is considered in a dangerous condition. Several other persons received severe contusions from billets of wood, but none of them are dangerously injured. The body of Mr. Parker was taken to Ravenna for interment.

The "Portage" has been running on the road between three and four years, and was considered a safe machine. We did not learn the cause of the explosion."

The above case requires but little comment. Every person that has ever seen locomotives and has observed their construction, can not but see, (taking simple steam expansion into consideration) that it required a much greater force to shiver to atoms a locomotive,

besides destroying the tender, which was beyond the reach of the steam expansion in the above case.

The "Reindeer" exploded * * 10 miles below Alton, on the 7th of April, 1855.

This is the fifth explosion since the 1st of January, up to the 7th of April An ominous commencement for the present year.

EXPLOSION OF THE STEAMBOAT "ANGLO-NORMAN," 8 MILES ABOVE NEW ORLEANS, DEC. 13, 1850.*

(*Explosion No.* 3.)

The "Anglo-Norman," it appears, was a new boat intended for a tow-boat, and had been proven by three trips, from the gulf, with tows; the fourth and fatal one seems to have been an excursion trip, in which many of the influential gentlemen of that city participated. The boiler was of the wagon form, 30 feet long, 16 feet wide and 9½ feet high, weighing 28 tons. This boiler is represented as of good workmanship, and as "Mr. Jones, Civil Engineer" thinks, should have borne 50 lbs. per square inch pressure, instead of 24 inches of the murcury gauge under which it exploded. It is ascertained by calculation that a cylinder boiler 16 feet in diameter, will bear 50 lbs. per inch pressure, as well as one of 40 inches will bear 225 lbs. and this is by no means more than half the pressure of simple steam, which a good boiler ⅜ inch plates and 42 inches in diameter will bear before rupture takes place. Consequently it would require at least 100 lbs. in a 16 feet boiler of good ⅜ inch iron. No one however, should deceive himself with these figures, for let it be remembered that they refer to simple steam alone. At one half or even one tenth the above figures, the elements within a boiler, may at any moment unite with an explosive element, forming an instantaneous explosive force of from 1000 to 30,000 lbs. to the square inch. The boiler in question was not cylindric, but the wagon form, in which case the side plates, in consequence ot the arches or stays giving way, would incline, under the within pressure, to extend outward to a cylindrical form. It is not likely that 24 lbs. pressure caused these arches to yield, and if such were the case, it would only end in a rupture which would have caused but little damage, for in the extension of the shell with the consequent leakage the internal pressure would have been reduced considerably below 24 lbs. so that the remaining force within, it is believed would not have raised the boiler off its foundation; for example,

*A full account of the explosion is given by A. C. Jones, 21 vol. Journal of the Franklin Institute page 51.

app.y the law of steam expansion, and it will be seen that all the simple steam that was in the boiler at the time of its explosion, could have been confined in an exhausted paper cylinder 30 feet long and 14½ feet in diameter. The agent that cleared the Anglo-Norman of 28 tons of boiler, must have been one of more power than simple steam at 24 inches of the mercury guage pressure. In this explosion no part of the boiler remained on board to bear evidence of its fractures. As the top of the wheel house left evidence of being in contact with the boiler, it is probable that it was carried over the top of the boat. "Those on board testify that there was plenty of water just before the "the explosion." "By the testimony of the Captain and others, of "the boat, given on oath, (at the inquest held over the body of Mr. "Stillman, of the Novelty Works, New York,) it was stated that the "safety valve was adjusted to blow off at 25 inches of the mercury "gauge, and at 26 inches the steam would blow off freely; which was "the case before the steamer left the wharf on this excursion trip." "That there was no neglect in the management of the boiler, seems "certain, for there were too many practical men not to notice if such "were the case; all who knew the first engineer, Mr. Samuel Hill, "speak of him in the highest terms of his professional ability, "and give him the rare quality of being over cautious; he received "the cause of his death at his post along side of the engine, which "he only left from time to time to pass quickly to and from the fire "room. It is confirmed by different persons, that there was a dis-"charge of water and steam from the safety valve pipe an instant "before the explosion."‡

In this case there was no incompetency of engineers, recklessness, or racing; no shallow water level; no incrustation, no adhesion or fastening down of the safety valve; no cold or hot water thrown upon unduly heated metal; nor was there any over-heated plates to weaken the shell; neither was the pressure more than half what the boiler should have borne. Nothing of the kind is reported. "But the inference was that one of the middle arches gave way from the pressure which the steam exerted on its side." There are two important circumstances connected with this explosion, which must not be overlooked. First, it will be recollected, that the testimony given (by the Captain and others,) that the safety valve was adjusted to blow off at 25 inches of the mercury guage; and at 26 inches the steam would blow freely, which was the case before the steamer left the wharf on the excursion trip. This clearly shows that the boiler bore more simple

‡A. C. Jones, Franklin Institute.

steam pressure at the wharf, than it indicated by the guage just before the explosion. Now if the boiler was exploded by simple steam pressure either from defective metal, arches, stays, or otherwise, such according to natural law would have been the case at the wharf, when the steam indicated its highest figure on the mercury guage ; for at that place the boiler sustained the greatest steam pressure. Perhaps it will be contended that the boiler, or some parts thereof, had received a strain, or fracture, at the wharf when under the greatest steam pressure, yet the boiler held together, until relieved of its pressure, and finally exploded in consequence of such injury under a less pressure. Such logic will not stand the test of close criticism. A human being for example, may grasp hold of an object, relax and grasp with the same force again. Metal is held together by cohesion; if force be applied to a certain degree, the fibers will commence separation ; continue such force for a few moments, and separation of fibers will be final. These fibers do not partially separate, yet support the same force in that condition, and afterwards in the same condition of strength yield under the influence of a minor force. Second, it is confirmed by different persons, that there was a discharge of water and steam from the safety-valve pipe an instant before the explosion. This is proof clearly, that there was a combining of explosive elements which united in the water and steam, causing an instantaneous explosive pressure in all directions ; forcing the water and steam in a convulsed state in in all directions, the safety-valve being the weakest point, gave indications first, by opening and discharging water and steam. If the boiler had exploded by forcing out the sides in consequence of an arch giving way, or otherwise, from simple steam pressure beyond the strength of the boiler, there would no discharge of water and steam have been seen from the safety-valve. For this would not have caused any commotion in the steam and water, only a gradual pressure would have been the consequence thereof.

There certainly is no reason for the safety-valve lifting, if the boiler was defective otherwise, and gave way in consequence of that defect.

EXPLOSION OF THE STEAMER "KNOXVILLE," AT NEW ORLEANS.

(*Explosion No.* 4.)

Communicated to the Franklin Institute, vol. 21, by A. C. Jones, from which a few extracts will be made. * * *

The Knoxville lying at the levee, exploded two (of her four) boilers, destroying many lives and making a complete wreck of the boat, and also doing much injury to other steamers in the vicinity.

All the main deck which was under the boilers, and most of the guards are destroyed, every thing overhead forward of the engines was carried away, and its innumerable fragments cover the surface of the water, and the adjoining boats. A (new) monometer or pressure guage was in good order; its cock communicating with the steam pipe, was open at the time; the range of the scale was 160 lbs.; that is it would indicate no higher. * * *

One inside boiler, 26 feet long, and 42 inches in diameter, left the "Knoxville" nearly at right angles, and, after breaking the guard of the "Martha Washington, lying along side" its foward end passed upward, and through the cabin of this boat, leaving a breach of 12 feet wide, and thence making its way through the side of the "Griffin Yeatman," and landed in the ladies cabin, bottom up. * *

The larboard outside boiler took its flight from the boats end, and at an (horizontal) angle of 120° from the course taken from the other boiler; at 295 feet, it came in contact with the end of the third tier of flour barrels 45 feet, on it passed through another pile of barrels, destroying many down to the first tier. Here it diverged 18° and continued on 200 feet more, where it rested on the ground. This boiler gives evidence of inferior iron, and low water lines, some parts of the iron is full $\frac{1}{4}$ inch thick, other parts but little over $\frac{1}{8}$. The gas theory having almost evaporated, we have now par excellence "the state of the atmosphere," given as a reason for explosions, but in this instance, I feel safe in stating the causes were defective boilers; a deficiency of water, and ignorance on the part of the management. That the water was low, is evident from the sharp sound of the explosion, and from the almost perfect boiler in its passage through the cabin of the "Martha Washington," scarcely soiling the white paint by water; none was discharged on the Griffin Yeatman's deck, neither did the other boiler discharge any water in its track, over the land, it also was dry. * * *

This explosion seems to have been another of those dreadful magazines of nature, in which was manifested, to an enormous degree the explosive combination of her elements. Simple steam pressure had nothing to do with this case. From the dreadful consequences developed it was, undoubtedly, the result of the instantaneous developement of explosive elements with an expansive force, equal, to from 20,000 to 30,000 lbs. per square inch. Only think of it, here was a force which projected a whole boiler 26 feet long and 42 inches in diameter, against the guard of another steamer, breaking it, then passing upward through the cabin of this boat, leaving a breach 12 feet wide; then on to the next steamer, passing through its side, and landing in the ladies cabin. Another boiler takes its flight from the boat, (at an angle of 120° from the course the other was projected,) passed on in a horizontal line 295 feet, came in contact, at this point, with the third tier of flour barrels, injuring them, then 45 feet farther it passed through another pile of barrels, destroying them down to the first tier, there it

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diverged 18° and continued for 200 feet more, making about 540 feet on a horizontal line through those several piles of barrels. Was this the effect of simple steam, generated under this (new) monometer or pressure gauge, which, we are told, would only indicate 160 pounds! It is further stated that the boilers were made of very inferior iron, besides being little over $\frac{1}{8}$ inch thick in places. If such were the case, that the boilers gave way on account of their defect, it would naturally follow that it required but low pressure steam to rent those defective boilers, that the result would not have been so terrific as to project a boiler 540 feet through obstructions, besides strewing the river and boats in the vicinity with innumerable fragments of the wreck. Again we are told that the water was low, from the sharp report; this seems as though it required great power to rupture those boilers, that were so deficient in texture and thickness. The truth of the matter, as it is given, involves a gross absurdity. There is no human being that can tell whether the water was low or not, in those boilers, just before the explosion took place. Such has been the case in two instances, in experimenting, namely, that the steam and water disappeared in a short time.* It, however, may be calculated by mathematical computation, how far, all the steam that those boilers could contain, fell short of the power necessary to project the boilers as stated in the foregoing report.

TERRIFIC EXPLOSION ON THE STEAMBOAT REDSTONE,

On the 3d of April, 1852, 12 *miles above Madison, at Scotts Landing.*

(*Explosion No.* 5.)

Upon arriving at Scotts Landing, she was called out for a passenger. * * The Redstone shoved out and backed down from the landing about one hundred yards. A strong wind was blowing in shore, and it was with difficulty that she could back her way out. At the second revolution she made to start forward, her three boilers exploded at the same time, with a tremendous noise. She sunk in less than three minutes, in twenty feet water. * * In the explosion, her chimneys were blown nearly across the river. The awful force of the explosion can be conceived from the fact that a large piece of one of the boilers was blown half a mile, lacking "five or six yards," from the wreck. Eleven bodies were blown into a cornfield at some distance from the water. * *

The river for some distance below Carrolton was strewn with the fragments of the boat, machinery, furniture and clothing. Small pieces of bedding and clothing were found at the distance of very nearly half a mile back from the river, while the trees along the shore were littered with the fragments of the same and of the wreck. The cause of this explosion is very evident it was "recklessness."† * *

*See experiments.
†Scientific American, vol. 7, page 242.

Extract of an account given by Thomas Bakewell, Esq.

"The boilers, as arranged in the boat, side and side, about 3½ inches "apart, are connected near the fire end by a double concave cast iron "washer, 7 inches diameter, with a hole in the middle, 2 inches "diameter, to meet corresponding holes in the boilers, for a water pas-"sage, the joints between each side of the washer and boiler being "made with lead. This kind of joints is over the fire, and apt to give "trouble in ordinary circumstances by the lead melting out. Now, a "piece of each of the two boilers, still connected as above described, "was found and examined by myself and others, the lead joints of which "were perfect. We also found the lead joints of the manhole and con-"necting cross pipes in their original perfect state. From the above "facts, it is evident that the water must have been at least three inches "above the middle of the boilers, and would cover, (or nearly so,) "the flues."*

Extract of a letter from Mr. Sopher—the clerk of the boat.

* * * "At the time the wind was blowing hard ashore, and "instead of backing out as usual, she only commenced backing down "the shore, the wind prevented. The captain then gave the order to "stop backing, and go ahead, on the starboard wheel, that being the "wheel next to the shore, instead of going ahead, the "engine caught "on the centre," and while the engineer was working the levers, two "of the boilers exploded. I am unable to say how much we had on "at the time, but usually carried 140 lbs. and have had on as "high as 170 lbs. which was the most I have ever known. Nor "can I tell you anything in regard to the water, as the first engineer "of the watch was killed. The opinion of Capt. Pate was, that the "water must have been low."†

This explosion needs but little comment. To the reasoning faculties, it is conclusive that in this case again, (as in former cases,) explosive elements have combined and formed a terrible magazine, which the result clearly shows. The old hypothesis, which is in almost all cases of explosions brought up, to-wit: low water and unduly heated metal, will fail again in this case. Human testimony is often unreliable,—but in this case we have evidence which is incontrovertible, that there was no unduly heated metal, namely, the "lead joints," spoken of by Mr. Bakewell. Lead becomes fusible at 594° Fah'r., which is below a red heat. This is evidence that the water at the time of the explosion was above those lead joints, and their height on the boilers will be seen by reference to the above. It is also stated by Mr. Sopher that the highest steam pressure that they ever used was 170 lbs, let this be as it may. Suppose they did in this case have simple steam sufficient to rupture those boiler plates, which would have probably required, if they were good boilers, 500 lbs. per square inch pressure. How far short, dear reader, would such a volume of compressed steam

* Journal of the Franklin Institute, vol. 23, page 413.
† Journal of the Franklin Institute, vol. 23, page 414.

(even if let loose instantaneously,) have been to project the chimneys, (as above stated,) nearly across the river, (the boat being at one shore,) and a large piece of a boiler a half a mile, lacking six yards, and eleven bodies into a cornfield at some distance from the water, and some pieces of bedding and clothing very nearly half a mile, besides, littering the trees along the shore with fragments of the same, making a complete wreck of the boat, and leaving the river strewn with fragments of the boat, machinery, furniture and clothing for some distance below Carrolton, which was four miles below the wreck? Reason and analogy will answer, without any further calculation, that 500 lbs. per inch, simple steam pressure within two cylinders, (half filled with water,) 42 inches in diameter and 30 or 40 feet long, (as the case may be,) had nothing to do with such an awful catastrophe. The steam therein contained, if let loose instantaneous in a vacuum, would not have expanded more than six feet from the shell of the boilers. This thing of stopping the engine is a dangerous practice, besides being so unfortunate, as to have it hang on the centre. Every moments delay increases the danger of those elements uniting explosively, which was the case with the foregoing explosion.

SINGULAR EXPLOSION.

From the Scientific American, Feb. 16, 1850

(*Explosion No.* 6.)

* *—At Mr. D. Smith's Paper Mill, a large egg shaped boiler, used for boiling rags, made of stout boiler iron, and weighing about 4 tons, was filled in the afternoon for boiling, by putting into it about two tons of rags, and a half barrel, or about 500 lbs. of soda ash and two barrels of lime soda ash, previously disolved in water, and water put in sufficient to cover the rags—the whole not filling it quite full. It was then all closed tight with the exception of a small hole at the top, which was left open until it began to boil, then plugged up. It was heated by steam brought through a three inch pipe, from a distance of eighty feet from the steam boilers, and was situated in a small building 30 feet from the side of the main building. After boiling about five hours, it exploded, tearing off a part of the bottom, which was thrown without touching the mill, high over the top, and landing 300 feet from the place it started from. There were two distinct explosions or reports, and the fireman says that the brick came with the second report, though it was not as loud as the first, and he had just previously turned off a part of the steam. The steam is generated in six boilers, and but a small part is used to boil the rags, the rest being used in the cylinder of the paper machinery to dry the paper. The building in which this rag boiler was situated, was shivered into fragments, and another boiler situated by the side of this one, and apparently filled in the same manner, and boiling at the same time, was left uninjured with the exception of being moved a few inches. A

large iron wrench that was left on the top of the boiler, was carried with it the whole distance. Some of the rags and hot water were thrown as high as the top of the mill, which is four stories high. * *

This explosion dissolves the whole catalogue of causes, as usually referred to, by those who think that steam boiler explosions might so easily be obviated. Similar to No. 1, it, however, had, (according to their theory,) one cause left, that of a weak place by a "steam dome" which yielded to the pressure within. In the above case, even a slight cause similar to it, cannot be established. There being no steam pressure to act against the shell. Now what was the cause of this explosion? Undoubtedly the same agent that "violently" exploded every steam boiler that ever exploded, was evidently the cause of this. None of the usual branches of that unfounded hypothesis will answer, which attributes all explosions to some one or more of the many causes which are gotten up, so that if one does not fit the particular case under discussion, some other one, or more, may come in right; such as ignorance, recklessness, excessive pressure, defective metal, bad workmanship, ill construction, low water, and many others, which are sometimes resorted to. But in the above case they must uniformly fail to account for the true cause. As this case is so plain and self-evident, it is deemed unnecessary for any further comment.

(*Explosion No.**7.)

Two explosions of steam boilers took place in Cincinnati, in August 1849, one at the foundery of Pollock & Jones, the force of which threw the boiler some thirty feet from its bed, and the heavy iron shaft of the engine directly through the foundery into the street. The explosive force fortunately was directed upwards. There was a perfect shower of brick-bats all around for half a square. * *

(*Explosion No.* 8.)

The other was the collapsing of a flue of the boiler at Messrs. Ambrose & Rose's Planing Mill. The boiler was thrown some 400 feet, passing through several shops, and finally landing in the second story of a frame house. A man named Valentine, was carried 60 feet in advance of the boiler, and dashed to pieces.* * *

EXPLOSION OF A BOILER AT MADISON, IND.

(*Explosion No.* 9.)

* * The boiler was a vertical one, of cylindrical form, with the furnace in the center, and the heating force running up through the interior in a conical form. The boiler was 8 feet long and 3 feet in diameter, with a sheet iron chimney long enough to reach 20 feet above a three story house. The flue was 3 feet at the bottom, and

*The Scientific American, Vol. 4, Page 397.

only 12 inches at the top, having only about 3 inches of water space at the bottom of the boiler. The house in which this boiler was placed, was blown to atoms—not a brick or stone left unturned. The boiler itself was forced up in the air to such an astonishing height that it appeared in size, like a lard keg, to those who witnessed it. It fell three hundred feet from the place where it exploded. * * * In the shop where the boiler fell, a bench was broken where a man had been working, only a second before. It is supposed that the boiler was projected at least 1000 feet high into the air.*

It will only be necessary to examine the above, and compare the projectile force required in projecting those boilers, &c., with that of steam expansion.

EXPLOSION OF THE STEAMBOAT TIMOUR.

(*Explosion No.* 10.)

The "Timour" exploded her boilers near Jefferson, on the 2nd of August, 1854, while lying at the wharf. The doctor, or pump was in operation, there was plenty of water in the boiler, and steam was blowing off. Some of the pieces were thrown 200 feet high and 160 yards horizontally.

It appears that C. W. Melard, and J. R. Scott, Engineers of the Steamboat Timour, who have been tried before B. F. Hickman, U. S. Commissioner, for the Missouri District, on charge of man slaughter, misconduct and inattention to their duties as Engineers, have been acquitted of these charges.

And well might they be acquitted as far as the guilt of the explosion is concerned; for no being on earth had control over the terrible elements that combined in those boilers. Men will yet learn that Engineers have to often been censured for explosions over which they have no control.

In the above case, no one present could have had the least idea of danger, as the boat was at rest, the doctor in operation supplying water, and steam blowing off. However, if the engines had been working off steam, this explosion might have been avoided, for such might have prevented the accumulation of the explosive elements.

(*Explosions No.* 11.)

While writing of these terrific explosions, an electric wave conveyed the sad intelligence of two more disastrous explosions, one below New Orleans, the tow boat "Thomas McDaniel," and the other the steamer "Pearl," near Sacramento, California.

It is not intended in this work to relate any of the awful sufferings that have resulted from many of these explosions, or the loss of life, further than is necessary to show the great force of these explosions,

*Scientific American, Vol. 10, Page 11.

from the projection of human bodies as well as other heavy pieces of material, as human language would fail to describe the scene even in this last case, besides it would be touching the tenderest emotions of the readers mind unnecessarily. The account from there says that the fore part of the steamer "Pearl" was torn into ten thousand pieces.

The "Thomas McDaniel" had two vessels in tow, at the time her boilers, six in number, exploded, making a complete wreck of the boat, besides injuring the vessels she had in tow. It should be remembered that her six boilers exploded at the same time, which is an important argument, that will hereafter receive attention.

(*Explosion No.* 12.)

The "Augusta," in December 1838, burst her boiler, which, with the machinery, was broken to pieces. Nearly the entire main cabin was swept away, including the social hall and its appurtenances; a small partition next to the ladies' cabin being all that was left. * *

(*Explosion No.* 13.)

The "Black Hawk" exploded three boilers on the Mississippi river, blowing off all her upper works forward of the wheels. * *

(*Explosion No.* 14.)

Big "Hatchee" burst her starboard boiler as she was leaving the wharf at Herman, on her way to St. Joseph's, which passing aft, through the cabin floor and up through the hurricane deck, made a perfect wreck of the boat. * * * *

(*Explosion No.* 15.)

"Clipper No. 1," September, 1843, burst her boilers at Bayou Sara, making a complete wreck of the boat and destroying every soul on board. * * * She was backing out from her moorings, when the explosion took place; all her boilers, five in number, bursting simultaneously. A watchman alive, was thrown 100 yards, through the solid wall of Baker's hotel into a bed. * *

(*Explosion No.* 16.)

"Josephine," May, 1845, when 16 miles below Madison, burst. A part of her engine was driven with tremendous force into one of the state rooms, passing thence through the hurricane deck, disappeared in the river. * * * *

(*Explosion No.* 17.)

"Lucy Walker," * * when five miles below New Albany, blew up, * * while engaged in making some repairs, the water in the boilers got too low, and about five minutes after the engine ceased working, her three boilers exploded with tremendous violence. The explosion was upwards, and that part of the boat above the boilers

was blown into thousands of pieces. She was in the middle of the river at the time, and parts of the boat and boilers were thrown on shore. * * Pieces of the boilers not thicker than half a dollar, were found on the Kentucky shore.

(*Explosion No.* 18.)

The Tow Boat "Grampus," exploded on the 11th of August, 1828, about 8 miles below New Orleans. She had six double flue boilers which were all blown to pieces and overboard. * * *

(*Explosion No.* 19.)

The "North Star" exploded on the Black Warrior river, about 10 miles below Tuscaloosa, in 1841. This was another awful explosion, which occurred as the boat was leaving the shore and about starting ahead. She had three boilers which were all torn to pieces, and some parts thrown to some distance into a corn field. * * *

(*Explosion No.* 20.)

The Steamboat "Wilmington," exploded a few miles above the mouth of the Arkansas river, in 1839. The explosion was of the most destructive kind; her boilers, three in number, were all blown to pieces. The boat sunk and was a total loss, with full cargo. * *

(*Explosion No.* 21.)

The Steamboat "Buckeye," exploded about 10 miles above Randolph, on the Mississippi river, in 1830. This was another gunpowder explosion, which carried destruction in every direction. Her boilers three in number, were completely torn to pieces, and some large fragments were thrown some two hundred yards into a corn field. The boat was badly shattered. * * *

(*Explosion No.* 22.)

The Steamboat "General Brown," exploded at Helena, on the Mississippi river, in 1837. This was another awful and destructive explosion. Her boilers, four in number, were nearly all blown entirely to pieces. The boat was made a perfect wreck. * * *

(*Explosion No.* 23.)

The Steamboat "Marquett," exploded at New Orleans, in 1842; she was in the act of starting from the wharf, and just after the engine had started, her boilers, three in number, were completely torn to pieces and the boat was so badly shattered that she sank imdiately. * * *

(*Explosion No.* 24.)

The Steamboat "Cherokee," exploded at Lewisburg, on the Arkansas river, in 1840. The boat had landed to put out some freight and passengers, and in shoving out, and before the engine had made more than two or three revolutions, her boilers, three in number, exploded with such violence, that the boat was completely shattered to pieces, and sank immediately. * * *

(*Explosion No.* 25.)

The Steamboat "Tiger," exploded on the 16th of July, 1844. She was towing over the bar, at the mouth of the Mississippi river, the bark Marcia, when all her boilers, six in number, burst, and were blown over board. * * *

(*Explosion No.* 26.)

The Steamboat "Tuscaloosa," exploded on the Alabama river, about 10 miles above Mobile, in January, 1847. This explosion happened while the boat was under way; and had it been in daylight, a spectator on shore might have given a melancholy description of it—similar to that of the Moselle. But it happened in the darkress of the night, and at the time of a dreadful thunder storm. Her boilers, three in number exploded, carrying destruction in every direction. The cabin tock fire, and while burning, some powder caug! t which produced another explosion, and finally the boat sank. * *

(*Explosion No.* 27.)

The "A. N. Johnson" exploded, about two miles above Maysville. This may be reckoned one among those awful and destructive explosions. * * The boat was about landing, or had landed to put out a passenger, and before they got out under way again, all three of her boilers exploded, carrying destruction in every direction, and the boat was so badly wrecked that she sank immediately. * * *

(*Explosion No.* 28.)

The steamer "Blue Ridge" exploded but a few days after the "A. N. Johnson," near Galiopolis, on the Ohio river. This occured in a snow storm; the pilot had stopped the engine for some time; as he could not see to steer well, but, finally, he rang the bell to go ahead, and before tl e engine had made more than one or two revolutions, her boilers, two in number, exploded and sank the boat immediately. * * *

(*Explosion No.* 29.)

The "Wyoming" collapsed at Cincinnati wharf, in 1835. Her cast iron foward-head blew out with such wonderful force, that the whole boiler jumped from its bed, and passing through the engine room, and over board into the river. * * *

The above list of explosions from No. 12, to No. 29 inclusive, are extracts, from a report of steamboiler explosions. * They are given without comment, merely to show what awful magazines they have been. To this number a great many more might be added from other scurces, but it is thought that the above will serve as an example.

EXPLOSION OF THE "MOSELLE," AT CINCINNATI.

(*Explosion No.* 30.)

On the 20th of April 1838, between 4 and 5 o'clock in the afternoon, this shocking catastrop!:c occurred. * * *

On leaving the wharf at Cincinnati, the boat ran up the river to take in some families and freight. * * *

The landing completed—the bow of the boat shoved from the shore, at the second or third revolution an explosion took place, by which the whole of the fore part of the vessel was literally blown up. * *

The power of the explosion was unprecedented in the history of steam; its effect was like that of a mine of gun powder. All the boilers, four in number, were simultaneously burst. * * *

Fragments of the boilers and of human bodies, were thrown both to the Kentucky and Ohio shore; and as the boat lay near the latter, some of the victims must have been thrown a quarter of a mile. * *

A man with his head foremost, in falling, passed as far as his shoulders, through the roof of a house, distant 212 feet, and 59 feet in height above the edge of the water. * * *

Dr. Locke, who was one of the committee appointed to investigate the cause of this accident, came to the conclusion from the extra weight that was hung on the safety-valve, that at the time of the explosion, there must have been at least 500 lbs. per square inch, which according to calculation, was as much as such boilers could sustain. * * * *

Parts of the boilers were twisted up like leather, and thrown in every direction. One piece weighing 236 lbs. was blown 800 feet. * * * *

Another witness says, a portion of a boiler weighing 450 lbs., was thrown 170 feet; another 336 lbs., was thrown 480 feet distance This must have been projected to a great height, as it entered a roof which it broke through at an angle of sixty degrees. A third piece weighing 245 lbs., was driven 450 feet on the hill side, and 70 feet in altitude. A fourth piece weighing 236 lbs., was driven 800 feet. A fifth piece, 147 lbs., was thrown 330 feet off into a Tanyard

To understand the full force of these measurements, which were carefully made; it will be recollected that the Moselle, at the period of the explosion, was 116 feet from the edge of the water, and 192 feet from the top of the river bank. * * *

There can be but little doubt that the cause of this explosion, was simply the subjugation of the boilers, to inordinate pressure. It was ascertained that she came up to the raft under a steam pressure of 125 to 150 lbs., per inch; she lay there with boilers closed, and furnace as hot as dry wood could make it, for twenty minutes more. This must undoubtedly have more than doubled that pressure. There can be no dispute of the quality of the iron. Pieces of the boilers may be seen in the Cincinnati Museum, which determine the fact, that the iron drew out to half its thickness before the fracture took place.*

It seems from the above extract, that it was the firm conviction

*Report of Steam Boiler Explosions from the Commissioner of Patents to the Senate of the United States.

that those boilers exploded from simple steam pressure; the pressure being gradually increased until finally the shell yielded, causing the above terrific explosion. Such a terrific result, as that of the explosion on the Moselle, was not caused by simple steam pressure, even if it had been increased sufficiently to rent or rupture the shell of the boilers, which would have required from 500 to 700 lbs. per square inch. In case simple steam had been generated to a pressure from 500 to 700 lbs. per inch, rupture would undoubtedly have ensued, and that without projecting pieces, or doing any further damage.—And it is not likely that more than one out of the four boilers would have been ruptured, as it is not probable that four boilers upon the same boat would be exactly of equal strength, so that all four would rupture at the same time, or with the same pressure; the weakest one in such case would rent first, and this would relieve the others of undue pressure. Again if in the order of things it would have happened, so that these four boilers were constructed so as to bear exactly equal pressures, they would have caused no other damage than four ruptures at the weakest points. And in case it were possible for the shell of those four boilers to have opened out, and the steam therein contained, let out instantaneously, the expansive force in all four boilers combined, could not have extended beyond a space of 30 feet in diameter. With such elastic force, but little damage would have been the result. But instead of a simple steam pressure of 500 to 700 lbs. per inch, there was most likely in this case from 20.000 to 30.000 lbs. per inch pressure, of an instantaneous development from explosive elements. It will be seen that there is a great difference between these two forces. The former at 600 lbs. extends expansively only to an area of 30 feet in diameter, a distance entirely inadequate for the projection of pieces of iron and human bodies, as in the case of the Moselle. The latter at 20.000 lbs. extending explosively to an area of about 200 feet in diameter, a distance probably equal to, but not more than would be required for a projectile force necessary to throw heavy pieces of fractures, and human bodies, besides causing a perfect wreck of the boat as in the above case.

A thorough investigation of the law that governs projectile forces, is sufficient to decide the above case. It is stated, that pieces of these boilers after the explosion, were twisted up like leather. Such is not unusual with steam boiler explosions—it however, is not the case with a regular expansive force. This part of the subject will be treated under its proper head.

The following list shows the number of Steamboat explosions, that occurred in each locality, as far as reported:*

(*No.* 1.)

Alabama River,	9	James River	1
Apalachicola,	3	Lake Ponchartrain,	3
Arkansas,	3	Mobile	5
At Sea,	1	Mississippi River,	90
Blakely, Alabama,	2	Missouri,	5
Buffalo,	2	Michillimacikinac,	1
Baltimore,	3	Ohio River	41
Balize,	2	Potomac,	1
Black Warrior River	1	Rio Grande,	4
Charleston, South Carolina,	6	Red River,	2
Chattahoochee,	2	Savannah River,	4
Cumberland River,	2	Tombigbee,	1
Coal Port,	1	Waters adjacent New York	14
Champlain Lake,	1	Yazoo River,	1
Coast of Florida,	1		
Delaware River	4		225
Detroit,	1	Places not noted,	8
Elizabeth City, North Carolina,	1		
Gulf of Florida,	1		233
Galconda	1		
Gulf of Mexico	1	Mississippi river and its tributaries,	146
Galveston,	1	Southern and Western Waters,	202
Illinois River,	3		

DATE OF STEAMBOAT EXPLOSIONS.†

(*No.* 2.)

1816	3	1825	2	1831	2	1837	13	1843	9
1817	4	1826	3	1832	1	1838	11	1844	4
1819	1	1827	2	1833	5	1839	3	1845	11
1820	1	1828	1	1834	7	1840	8	1846	7
1821	1	1829	4	1835	10	1841	7	1847	12
1822	1	1830	12	1836	13	1842	7	1848	12

(*No.* 3.)

The Knoxville	exploded	2	boilers,
" Redstone	"	2	"
" Timour	"	2	"
" T. McDaniel	"	6	"
" A. N. Johnson	"	3	"
" Augusta	"	4	"
" Black Hawk	"	3	"
" " Diamond	"	all numbers not stated.	
" Blue Ridge	"	2	"
" Buckeye	"	3	"
" Cherokee	"	3	"
" Clipper No. 1	"	5	"
" Gen. Brown	"	4	"
" Lucy Walker	"	3	"
" Marquette	"	3	"
" Moselle	"	4	"
" Richmond	"	3	"
" Tiger	"	6	"
" Tuscaloosa	"	3	"
" Unity	"	all numbers not stated.	
" Wilmington	"	3	"
" La Fourchee	"	7	flues.
20		71	

Seventy one boilers exploded, at twenty explosions.

*Report of Steamboat Explosions to the U. S. Senate.

†Date given in 177 cases; not stated in 65 cases; total, 233.

Why is it, that of the explosions reported in table No. 1, that two hundred and two, or .867 per cent., occurred on the Southern and Western waters; one hundred and forty-six, or .626 per cent., on the Mississippi River and its tributaries; ninety, or .386 per cent., on the Mississippi River alone; forty, or .172 per cent., on the Ohio River?

There must be some reason, why, such a great per-centage of explosions has occurred on the above named waters, and especially on the Mississippi and Ohio rivers. It is said that the cause, and the only cause, is attributable to the reckless and ignorant character of Western and Southern boatmen; especially engineers and captains. Such arguments will not stand the test of logic. Are we to be told that there is such a great difference between boatmen of different localities? That the ignorant, and the reckless have so largely concentrated in the Western and Southern portion of the Union, and especially upon the Ohio and Mississipi rivers. But from table No. 2, it would appear, that the ignorant, and reckless character of those Western and Southern engineers, has been periodical; that during certain periods or years, there have been great variations with regard to number, in each year; for example, 1835, 36, 37, and 38, were unfortunate years. while 1839 shows the occurrence of but 3 explosions. A much better solution of the question is, to attribute these great percentages of explosions on our Western and Southern waters, to their specific localities, and peculiar state, or condition of the atmosphere—such will harmonize with the true character thereof. That certain localities at certain periods are rife with danger of those terrible consequences, is ascertained from the history of explosions, as well, as from certain experiments.*

Again, why is it that nearly all explosions occur while the engine is at rest, or at the second or third revolution, after it has been at rest for some time? In answer to this question, a number of hypothesis or conjectures have been resorted to, not one of them, however will be applicable in all cases—nor does it appear that any one has absolutely been established in any one specific case of explosion. The main causes comprising the hypothesis refered to, are the following.

First it is claimed that when the engine is at rest, boilers closed, fire in action, (as in case of the "Moselle) that the moment the throttle valve is opened to fill the cylinders, causing an instantaneous concussion or reaction in the boilers, when unduly charged with steam, an instant explosion ensues. Such is not the case; explosions according to the report of explosions do not follow on the first opening of the throttle valve, but, usually about the second or third revolution of the engine which shows that this supposed reaction, or

*With small Steam Boilers under different circumstances, by the author.

concussion has taken place, from four to six times usually before the explosion followed, besides filling the cylinders twice for each revolution, which would be (at $\frac{1}{2}$ cut off in two revolutions, with two engines,) four cylinders full of steam drawn from the boilers before explosions usually take place. This amount of steam drawn from unduly strained boilers, does relieve them to some extent of that great pressure, so that there is no reason for a boiler bursting from undue pressure, after the engine has made several revolutions. Another part of the theory, is, that when a boat stops to put out, or take on passengers or freight, while thus at rest, the fires wholly or partially in action, the water gets low from wastage, or otherwise, the boilers and flues become unduly heated—the steam pressure at rest causing the water to have a perfectly smooth surface—everything quiet; next the bell is rung for readiness; the engine is set in motion; the throttle valve is opened; the steam rushes to that point, causing a commotion in the water in the boilers, by relieving the pressure— in this upheaving of the water, the red-hot flues and side plates become immersed; this causing the water on the red-hot iron to be rapidly converted into steam of great elastic pressure an explosion ensues. Or in cases where this argument does not seem rational, it is claimed, (in place of internal commotion) that the doctor, or supply pump was put to action, jetting water upon those unduly heated flues, and plates, thereby causing the rapid generation of highly elastic steam, thereby causing those numerous explosions which take place just after the engine has made two or three revolutions.

The two last named causes must fall from the fact, that well directed experiments will show, that water thrown upon unduly heated iron does not evaporate instantly; nor does it vaporize upon unduly heated metal, as rapidly as when the temperature is reduced. From well directed experiments, it is evident that most rapid vaporization takes place at a temperature far below a red-heat.

There is, however, a reason why nearly all explosions occur after the engine has been at rest for sometime. It is a truth founded in physical analogy, and proven by well directed experiments, that steam boilers do explode by the accumulation of the explosive combination of certain elements within. This being the case, it is plainly seen why nearly all explosions occur after the engine has been for sometime at rest.

Steam machinery is usually so proportioned, that the cylinders exhaust the steam in the boilers, once from nine to fifteen revolutions, occupying usually from one-half, to three-fourths of a minute. The

engines thus exhausting the boilers, at least once every minute, gives but little time for some of those elements to accumulate in explosive proportion; because, as fast as these dangerous elements accumulate, they are uniformly exhausted through the cylinders, so that rarely enough accumulate, while the engines are at work, to cause an explosion. A similar reason is, why, locomotive explosions, are, less frequent than those on steamboats; as the cylinders of the former exhaust all the steam from the locomotive boiler, in a shorter period, than those of river engines. But there is also another cause, besides, why, locomotives are more exempt from explosions than steamboats, and this, is, that they are usually running in localities, where one of those explosive elements does not exist in such abundance, as is the case on some of our Western and Southern waters.

Another remarkable circumstance often occurs at steam boiler explosions, which is, that sometimes all the boilers on board of vessels, or otherwise, explode at the same instant. This may be seen from table No. 3, which shows that in twenty explosions, seventy-one boilers were exploded. If boilers explode from undue pressure, unduly heated plates, deficiency of water, or any other cause or causes usually attributed to explosions, (all of which may be resolved in the one theory, that the pressure within becomes too great for the strength of the boiler,) why does it so often follow that from two to five boilers explode at the same time, and in many cases all on board, even as many as seven? Is it good logic to suppose that in so many instances, where more than one boiler exploded, that they were in such cases, of such uniform strength, that it took exactly the same number of pounds per inch pressure to explode all, as it required to explode one of the number? Is it likely that even if some boilers were constructed of exact equal strength, that it would happen that they would be so equally mated upon the same boat in so many instances? Would it not seem more consistent to suppose that these terrible explosions are caused by some explosive elements, (of such power that no boilers, however, strong or weak can withstand) which in such cases are instantaneously communicated from boiler to boiler, through the connecting pipe? But, again, all the boilers upon a boat do not always contain the proportionate base of this explosive element; in such cases explosions could not result from a connection with the boiler, whose elements are in active explosion. Therefore such boiler would remain unexploded, while the one or more by its side containing the explosive base, would violently explode.

It is a law of nature, that the compression and expansion of atmos-

pheric air, depends upon the force applied in proportion to the space occupied. If a cylinder 48 inches long in the clear, closed at the bottom, into which a piston working air tight and free of friction is placed, it being drawn to the top end of the cylinder, admitting air in below by an apperture—after closing the apperture the piston is loaded with one atmosphere, or about 15 lbs., it will move downward till within 24 inches of the bottom when it will come to a stand; having compressed the atmosphere in the cylinder into one half its former space. If we then add an additional weight of 15 lbs., the piston will again move downward to within 12 inches of the bottom, where it will again be brought to rest; having by adding a double weight compressed the atmosphere, into one half its last named volume. If we next double the last named weight, which will be 60 lbs., the piston will again move downwards, until within 6 inches of the bottom, where it will remain stationary; having compressed the air into one half its last named volume. If we now reverse the experiment by removing one half of the weight of the piston, which is 30 lbs., it will instantly rise to a point 12 inches distant from the bottom. If another one half which is 15 lbs. be removed, it will rise to a point 24 inches distant from the bottom. If we finally remove the remaining 15 lbs., the piston will ascend to the top of the cylinder again. This law of compression and expansion, is applicable to steam boilers; because steam follows the same law of compression and expansion as atmospheric air does.

Steam boiler explosions in many instances present a scene of much greater destruction than that resulting from gunpowder—yet such terrific consequences are attributed to simple steam pressure.

Let us compare the explosive force of gunpowder, with the expansive force of simple steam. Proper mixtures of niter, wood-charcoal and sulphur, when ignited, explodes with a terrific report; while simple steam under a pressure of 500 lbs. per inch, if instantly set free, does not resemble it in the least.

The explosive force of gunpowder is at least 16.000 lbs. per square inch. "Dr. Ure estimates the explosive volume of gunpowder at more than two thousand, the explosive solid." According to this measurement its explosive force would be about 32.000 lbs. per square inch. But taking 16.000 lbs. as a safe estimate, and we have an explosive volume of 1024, its explosive solid—while simple steam at 500 lbs. per square inch pressure, will only yield 32 volumes, that is, it will occupy 32 volumes at the atmospheric pressure, instead of 1 volume at 500 lbs.—showing that steam at 500 lbs. pressure, will expand to 32 volumes, while gunpowder at the lowest explosive cal-

culation, will explode to 1024 volumes. One volume $\frac{1}{8}$ inch of gunpowder if ignited in a tube (of proper temperature, say 590° Fah'r. to prevent the rapid absorbtion of caloric from the exploded gas) will expand to 128 inches; while that of steam at 500 lbs. under similar conditions, will only expand to 4 inches. Now if this law be applied to steam (which it certainly is applicable to,) it will be seen at once, that the expansive distance of simple steam at 500 lbs. per inch pressure, in a 42 inch boiler, will not extend beyond a circumference of 63 inches from the shell, at which point it will be brought to an equilibrium in consequence of the atmosphere. This is the true law that governs the expansive property of simple steam; it expands if relieved from its confinement equally in all directions, until counteracted by the atmospheric pressure.

Reason would ask, how can such limited steam expansion, (even at a pressure of 500 lbs, that will rupture, or cause leakage in a boiler 42 inches in diameter, and $\frac{1}{4}$ inch iron) project large fragments of exploded boilers half a mile, lacking six yards,* and, whole boilers, on a horizontal line, to the distance of 540 feet, through several tiers of flour barrels, or through several of the neighboring boats.†

Those who attribute steam boiler explosions to simple steam, will say that those boilers, and fragments of boilers, were thrown to such great distances, by the momentum acquired during the few feet of steam expansion. Such logic must fall fruitless, under correct reasoning. The projection of bodies depend upon certain conditions of causes —that is, the force applied in combination with the distance, to the point of suspension, corresponding to weight, velocity, resistance, and degree of elevation, gives the exact range, or distance of projection.

It, however, does not require such mathematical calculations to ascertain, whether, the simple steam pressure that may be generated in an ordinary boiler, with a few feet of limited expansion, can project fragments of boilers, and even chimneys, nearly across the Ohio river;‡ causing locomotives (weighing twenty tons) to ascend up into the air some thirty feet, and making a summerset in the ascent, at the same time passing through the roof of the shed, under which it stood, and landing some sixty yards from the place of explosion.§

A man was projected 100 yards, through the solid wall of a house, into a bed.¶ It is not likely that this man was in contact with the shell of the boiler, at the time of the explosion, and therefore did not

* See the account of the Redstone, No. 5.
† See the account of the Knoxville, No. 4.
‡ The Redstone. No. 5.
§ The Irk Locomotive, No. II.
¶ The explosion of the Clipper, No. XV.

receive the momentum, necessary for such an enormous projection from a few feet of simple steam expansion.

Part of an engine was driven with tremendous force, into one of the state rooms, passing thence through the hurricane deck,into the river.*

Those who have any knowledge how far engines are usually located from the boilers, will certainly not attribute the preceeding case, to simple steam expansion, when the engine was situated entirely beyond the reach of simple steam expansion; besides being secured to the boat so firmly, that nothing short of the most explosive elements in nature, could remove it.

Again, it may be asked, where did this simple steam expansion obtain a fulcrum, to seperate a part of this engine, and project it through the boat, into the river—did the atmosphere serve as a fulcrum? It cannot be, steam at ordinary working pressure, or even at 500 lbs. per inch, (a pressure that will rupture most boilers,) when freed, expands too slowly to use the atmosphere as a fulcrum, to move ponderous objects. There is, however, a phenomenon connected with steam boiler explosions, which direct the explosion, often in certain directions; this will be noticed under its proper head.

A boiler 3 ft. in diameter, and 8 ft. long, was driven to such a great height, that it appeard to be the size of a lard keg, and was supposed to have been 1000 ft. high.† Applying the law of simple steam expansion to this case, we shall find that it falls far short of the necessary projectile force.

Again in the case of the Moselle, I will give the language of the report:

"The bow of the boat was shoved off, and at the second or third "revolution of the wheel, an explosion ensued, which destroyed every "part of her upper works as well as the machinery of the boat. The "hull drifted a considerable distance, and was landed just below the "city water works, where it sank a perfect wreck. The passengers "were unhappily on deck, and especially, as is usual, forward, as af-"fording the broadest platform; and were immediately over the "boilers. More than two hundred human beings of all ages and con-"ditions were instantaneously projected a prodigious distance in the "air. One man, with his head foremost fell, passing as far as his "shoulders through a house roof, distant two hundred and twelve "feet, and fifty-nine feet in height above the waters edge."‡

Here then we have another proof among the many in the history of steam boiler explosions—that simple steam pressure has nothing to do with it. In the above case—not only were the boilers most vio-

* The explosion of the Josephine, No. XVI.
† See explosion, No. 9.
‡ Report of the Commissonier of Patents to the U. S. Senate.

lently exploded and projected to both shores; but the machinery was entirely destroyed, besides moving the deck, loaded with about 10 tons of human beings, in the air, to such a great height, that some landed on both shores, while another broke the roof of a house in falling. Take the steam contained in the above four boilers, even at 500 lbs. per square inch pressure, and adding it into one volume, which will be about 570 cubic feet—at 500 lbs. pressure, if set free it will expand to 32 volumes, which will be about 18.000 cubic feet. Now if we make a calculation of the space around the boilers, (not taking into consideration the unobstructed openings in front and sides of the bow,) we have ample space for the instantaneous expansion of the entire volume of steam contained in these four boilers, without moving the deck upwards, or injuring a human being thereon. These two hundred human beings that crowded the deck, were out of the reach of the simple steam expansion contained in those boilers. With so many examples of this character in the history of steam boiler explosions, it is really surprising that men have not, long since, abandoned the old theory of such terrific explosions resulting from steam pressure. For all the branches of that "theory" may be resolved into this one, that of excessive internal pressure.

The boiler may be defective in material, or construction, or it may be unduly heated so as to weaken it, or it may be unduly charged with steam. Yet all these may be resolved into the one head, "excessive internal pressure." For say they, if a boiler explodes with 14, 24, or 50 lbs. per inch, it had a flaw, or stays gave way, or the plates were suffered to become red-hot, in consequence of a deficency of water, thereby diminishing the strength. It is, however, a singular fact in the history of steam boiler explosions, that often where the immediate cause of explosions, has (by the old theory) been attributed to unduly heated metal, defective material, defective workmanship, bad form—that most violent and terrific results were manifested. One would suppose that in case a boiler is so much weakened, by the presence of unduly heated metal, defective material, defective construction, or bad form—that of course it would require but low pressure to rend it—and that the result would be proportiontate—and would not project pieces half a mile.

It is the prevailing opinion, that steam boilers do explode from excessive steam pressure within; especially so, since the Committee of the Franklin Institute, of the State of Pennsylvania, have, in a report made to the Treasury Department of the United States, stated: "That all the circumstances attending the most violent ex-

plosions may occur without a sudden increase of pressure within a boiler."*

Here we have the whole theory in one sentence. But, unfortunately this committee has committed a great error, by selecting that deserted "quarry" for experimenting.†

In experimenting upon the causes and preventive of steam boiler explosions, I selected a spot whereon the atmosphere might be impregnated with foreign matter, or explosive elements, in order to ascertain whether there may not be a union of external elements, with the internal elements of a steam boiler, thereby causing explosions.

After these experiments, to my surprise, I found in a "report" on steam boiler explosions, that the above named "committee" had selected a similar place for their experiments, but for a different pupose.‡

They undertook to ascertain what sort of bursting would be produced by simple steam pressure, the pressure being gradually increased. They produced two violent explosions, one a copper, and the other a iron boiler, on the first trial in this deserted stone quarry—which seemed to them justifiable in uttering the above sentence. At another time they undertook to repeat Mr. Perkins' experiment.§

It appears that they went in a quarry pit, adjacent to that in which the cylindric boilers were exploded—and before the experiment was carried to the point intended, a violent explosion ensued, destroying the whole apparatus, so the experiment was abandoned.

"Mr. Perkins" experimented in London, and forunately in an atmosphere that was not impregnated with the element necessary for to produce explosions. Had he been with his generaters in that deserted stone quarry pit, the result of his experiments might have proven the forfeiture of his life—instead of producing a steam pressure of sixty atmospheres.

Is that "committee" certain that it was correct in stating, that those boiler explosions in that stone quarry pit, were the purely result of simple steam pressure? Are they certain that there was no foreign element present, that penetrated or combined with the elements within those boilers which so violently exploded?

* Journal Franklin Institute, 1836, page 225.
† The place selected for the experiment, was a deserted quarry, on the banks of the Pennypack, near Holmesburg. The high bank served as a protection, by the aid of which the experiments were viewed with little danger.
‡ To secure the experimenters against danger, the high bank obviated it.
§ Journal of the Franklin Institute, 1836, page 223.

PART II.

All changes in nature, may be classified with polarity, under the principle of positive and negative, attraction and repulsion, combination and analization, origin and ultimate, growth and decay, cold and heat, expansion and contraction, light and darkness, cause and effect, etc., ect. The student of nature, will see that her infinite variety of changes are the result of parent or original principles; that original principles forms the base of subsequent changes. These phenomena may be traced through all the forms of material existence—all formations, and all results in nature, are impregnated with these principles. Polarity as classified under the above heads, may be traced to the convolution of matter. The innumerable globes that are existing throughout space, are the necessary result of polarity. That polarity was established in the existence of matter anterior to the convolution thereof, is manifested throughout all subsequent formation. Without the existence of polarity in the primary constitution of matter, subsequent convolution could not have taken place.

Motion, owes its existence to polarity—without which, material worlds, or globes could not have been formed. Matter would never have changed from its original state without motion. And motion could not have been transmitted to matter without "positive and negative"* principles, to move it, or in any way effect a change.

The existence of polarity with positive and negative principles, seems to imply, antagonistic or opposite principles in nature. Such, however, is not the case—in nature these principles imply harmony—and tend to the development of subsequent formations. Having, then, from causality, access to some of nature's original natural principles or laws, we can without difficulty trace many of her phenomena, to their legitimate causes and corresponding effects. That which

* The term Positive and Negative is only used in the absence of a more appropriate one.

is a development of parent causes, (all things taken into consideration,) must present a close analogy thereto. And in like manner, if polarity effected the convolution of the matter that composes this globe with all its elements, then this globe, (frcm analogy, with all its material elements, either in the solid, liquid, gaseous, or aeriform state,) must present a corresponding analogy throughout all subsequent changes, or developments.

Is it a truth, or, is it but a fabulous theory, that all material nature, is impregnated with the principle of original polarity? let the experience of the world, with all its well directed experiments answer. The true astronomer can discover the principles of Polarity in every direction of the siderial heavens, to which he can direct the gigantic vision of his telescope. The whole science of astronomy owes its entire existence to the principle of Polarity, without which, none of those innumerable luminaries with their appendages could have been brought in motion.* The natural philosopher discovers that nature is everywhere impregnated with this principle. So with the true anatomical physiologist, he can even trace in the human "brain,"† (which is the highest in the scale of material developments,) the principle of original Polarity. The Geologist, Mineralogist, the Botanist, and even the Metaphysician, cannot establish the real fundamental principles of their favorite researches, without the acknowledgement of this universal principle. While the chemist discovers that his branch of the great science of nature is entirely composed of this original principle of nature—not a step can he advance in analyzing or combining the elements, without observing this principle in its various phenomena of Positive, and Negative, attraction and repulsion, expansion and contraction, etc., etc. Meteorology testifies that all substances that are in an aeriform state, are subject to this primary law of "polarity." Within the limit altitude of the atmosphere, there are innumerable columns that extend from different heights, down to the earth. These are composed of materials that float in the atmosphere, and are composed of the ingredients of various decomposed substances, such as animal and vegetable matter, under various circumstances.

These substances are on the principle of attractive, and repulsive conditions, concentrated to form extensive columns of cylindric form,

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*All suns, planets and satelites, throughout the immensity of space, are propelled in their eccentric orbits, and are governed in their concentric state, upon original transmitted polar principles, is evident from a careful investigation of the movements of the planetary universe.

†The human as well as the animal brain, performs its numerous functions upon a highly refined polar state; all our thoughts and feelings are founded upon these principles—we love, because it seems agreeable, we hate because it seems adverse, or disagreeable—happiness in thought is attractive, while its opposite is repulsive, so with all our mental actions, they are but the result of this original universal law of nature.

which may strike the earth perpendicularly, or at any angle with a horizontal line—and are only localized for certain periods—when they will again be dissolved by the change of their polar conditions, and transmitted to other localities; or they may become combined with other elements, and their peculiar composition lost in the progressive energy of nature. These columns of aeriform matter have one pole in contact with the earth, while the other is often a great distance from it; if they are composed of miasma, or poisonous matter they produce epidemics of various characters, corresponding to their peculiar constitutions. Thus, it is often the case that epidemics are raging over certain localities, either of a circular, elliptic, or other forms, in conformity with the angularity of the base of the column, and its affinity for the peculiar district or locality. Thus in crowded cities, and especially in those parts thereof, where filth, and debility prevails —(which forms a natural base for these poisonous aeriforms,) will these columns dip down and remain until exhausting the base—which is a foul state of the locality, either from filthiness of the inhabitants, or from a peculiar geological and atmospherical combination: in either case there must be a polar affinity between the specific locality and the axis of the peculiar aeriform trunk or columns. There are no material instruments constructed, that will define with certainty the existence and extent of these aeriform trunks or columns of surcharged effluvia; the human constitution under proper circumstances, is the only indication. An individual who has for a number of years, been a vegetarian, and has obeyed nature's laws in other respects, is a perfect aerimeter, and can tell the existence and extent of these unhealthy aeriform miasmatic columns—it produces a peculiarly uncomfortable sensation upon his constitution, that warns him of danger.

Again there are other phenomena connected with this subject, such as "Meteors" and "Aerolites." Meteors have excited much attention among natural philosophers, a number of hypothesis have been resorted to, in order to account for their origin. Some have supposed that meteors or shooting stars, originate in space beyond the extent of the earth's atmosphere, and only become luminous on entering the atmosphere. It is however, very consistent with analogy, that they are of terrestrial origin, and belong to our atmosphere, as other aeriform phenomena do. There is a perfect analogy between meteors or shooting stars, and the miasmatic columns—with this difference however, that the meteor is of a different combination of materials, which are highly combustible, and under certain conditions of polar, or positive and negative principles, combustion takes place,

which causes their luminous appearance—and decomposes their combination throughout their whole length with amazing velocity. Meteors are composed of the concentration of combustible materials of a trunk or tube form of small diameter, and of great length, is evident from their amazing velocity—which is ascertained to be from 18 to 36 and in some cases 45 miles per second—which at the latter figure, would be over two hundred times the velocity of a cannon ball. With such a velocity, or even one fourth thereof, if, it were a substance, (as some suppose,) projected from without, like a rocket, the atmosphere would not yield, but would under such velocity be as resistless as a rock. Therefore the conclusion must be, that they are volumes, of highly combustible materials in an aeriform state, of comparably very small diameter, but of great length—which peculiarity of length and diameter is owing to the peculiar polarity of the elements of such combination; and when combustion takes place at one pole, it will with immense velocity follow the volume of combustible element to the opposite pole, decomposing in its course the whole volume. Aerolites follow the same general law, but differ in several important respects. In the combustion of meteors or shooting stars, there is no fall of stones; all the decomposed substance enters into an aeriform state again. The explosion of large meteors, project fragments of their exploded masses in the form and appearance of stones to great distances—these are aerolites. The great meteor that appeared in New England on the 4th of December, 1807, which exploded with three distinct reports, like those of a four-pounder, dropped stones at six places, the most remote, nine miles apart. The fragments were from powder up to 35 lbs. From the fragments of one, it was supposed that it must have weighed 200 lbs.

The great meteor which passed over England, on the 18th of August, 1783, is said to have moved with a velocity of 2000 miles a minute, and finally exploded. Much speculation has prevailed among modern philosophers, concerning these aeriolites. "That these aeriolites, or falling stones are projected by lunar volcanoes within the sphere of terrestrial attraction," * cannot be correct; as the projectile force on the moon's volcanoes, would have to be of such an inconceiveable force as to project these great masses of stones over 6000 miles at least, before they would come within the earth's attraction. A much more rational solution, is to classify it with other known atmospheric phenomena. That they are concretions actually formed in the atmosphere, upon the foregoing principles of polarity, may be

* Theory of LaPlace.

deduced from well known laws.* How such solid and weighty bodies can be formed in the rare medium of the atmosphere, it will be asked. The reply is, that the elements of their composition were in an aeriform state prior to their solid state, and by the foregoing law of polarity, concentration of their constituent elements takes place, and in the act of condensation by polar affinity, combustion at the positive pole is the result, while the temperature produces incandescence; when the mass thus in active fusion is by polar affinity directed towards the opposite pole, and in traversing from pole to pole, the center of the fused elements of combustion repels the decomposed gas, while it attracts in its onward path, minute particles of aeriform matter—which are changed by the extreme heat, to their solid state, and deposited upon its main center; while thus forming and increasing in density, until reaching the opposite pole, when another condition of things takes place; that is, the elements of combustion are exhausted, the external temperature is lowered, contraction commences, while the internal temperature is incandescent, and explosion must follow. That their heat is extreme, and of a peculiar nature, appears evident, from the fact that fallen masses of stones were so hot, "that after six hours they could not be touched without causing a burn."† Volumes might be written upon these aeriform phenomena, but these examples will suffice for an illustration of our subject. Upon the foregoing principles, I will endeavor to maintain that the phenomenon of steam boiler explosions may be accounted for.

That the world may yet become acquainted with extraordinary explosive elements of this character, will be idle to deny. There are compound elements now known by chemists, of a fulminate nature, such as "chloride of nitrogen," of which 100 lbs. properly prepared, and properly distributed, would be sufficient to explode all the steam boilers on the Mississipi river, besides destroying its whole number of boats. Such are the effects of some of nature's elements, when developed from a latent state. And we have traces of the constituent elements of this compound in the atmosphere, besides many other explosive substances are in the atmosphere in a latent state, some of which are only found in certain Geographical localities; some of the most explosive, which could not heretofore have been detected by chemical apparatus, on account of their active penetrability. There are elements in an aeriform state, that will upon polar principles, unite explosively with other elements in the fluid state, under certain conditions of heat, which

* Chemical affinity of atomical nature upon polarity.
† Humbolt.

forms "fulminates" of the most extraordinary character, in explosive effect; differing vastly from gunpowder—acting upon the principle of the most violent reaction percussion from pole to pole, twisting, tearing, and scattering every thing within its explosive sphere; while that of the proper mixture of sulpher, charcoal, and nitre, (which forms gunpowder,) in explosion acts more upon the principle of expansion and projection. That there exists at certain times, in certain localities, elements in an aeriform state, that will unite explosively with water under certain conditions of heat, has been proven by well directed experiments.* And chemists will undoubtedly discover these aeriform elements, so soon as they can construct the proper apparatus adequate for the confinement thereof. These aeriform elements penetrate the ordinary metals, like light does transparent glass, or like caloric, or attraction, or gravity penetrates, or permeates other substaces.

The existence, and concentration of these aeriform elements, are analagous to those of miasmatic columns, meteors, shooting stars, aerolites; and resemble the former, especially in seeking by polar affinity, a base upon the earth, in certain localities, and under certain conditions. The polar tendency, of the minute particles of these aeri form diffused elements, is to form a centre, thence diverging in any direction, where a proper base for an opposite pole may be, which is often that of a steam boiler, with the water thereof in active ebullition. When it is the case that a steam boiler, (without an operating engine attached,) comes into polar affinity with a volume of such aeriform elements, the consequence proves terrific. If however, an engine is attached, and exhausts the steam rapidly from the boiler, or boilers, the terrific results are often obviated in consequence of these elements passing off with the steam, through the engine without reaching the water, especially if the steam is saturated steam, which forms a union with these elements, not explosively, but expansively, which only gives the engine greater power, and activity, with the exception, however, of sometimes exploding a steam pipe, or blowing out a cylinder head, or in case the steam becomes much saturated in passing from the boiler to the cylinder, in which case a violent explosion of the latter may be the consequence. But if the steam in the boiler, or boilers, is unsaturated steam, for which, these elements have less affinity, in which case they often penetrate, and come in contact with the heated water, when thus united and under certain conditions of heat, ebullition ceases, and the water takes a charge of the heat in a latent state; thence contraction of the water, and united el-

* The Authors.

ements takes place, when the whole volume, or a portion thereof, (as the case may be,) assumes a spheroid form, in which state of things, an explosion with all its terrific consequences, is near at hand. And it makes no difference, whether a steam boiler be situated on and, in, or outside of a building, these dangerous elements will find their way, in, as on a vessel on water, at rest, or in motion. The polar affinity may become established just as perfect, while the vessel is moving, as when at rest; with this difference, however, that when the vessel is in motion, or more properly speaking, if the engine is at work, there is less danger of an explosion, for the reasons before stated.

These elements vary in degrees of explosion, corresponding to perfect or imperfect state of combination, for example, if the whole volume of water in a boiler, or boilers, becomes completely impregnated with these elements, then the whole volume must explode, and the result will be most terrific; but, if only a portion of the water becomes properly united with these elements, the result will be proportionate.

It will be recollected that it was stated that the explosions under this head, act upon the principle of re-action percussion, and it should be further remarked that the explosive force, is often in a certain direction, which is in perfect harmony with other phenomena, such as electricity in its zigzag course; the meteors, aerolites, moving in certain directions, under the law of polarity.* So with the explosion in a steam boiler, if the explosion is limited, that is, if only a small portion of the water is charged with these aeriform elements, the explosive force, or percussion, may be directed upon the flues causing

* Tornadoes are caused and governed by the universal parent law of Polarity. The grand tornado, (like other electrical storms,) progresses from positive to negative, or from interior to exterior elements. Latent caloric belongs to the interior, or positive state of nature; while those elements which are in a perceptible state, compose the exterior, or a negative state of material nature; Upon this principle, latent caloric, from the interior state of nature, is developed and diffused among perceptible elements, in the exterior state of nature, thereby causing terrific commotions in passing from the positive to the negative, or from the interior to the exterior state of material nature.

Earth quakes and other subterraneous phenomena, may likewise be accounted for, by the above universal law. Such, however, conflicts with the views of those who assume that the ☞ Earth is a sphere of igneous fusion, (with the exception of an exterior crust, from thirty, to one hundred miles in thickness,) thereby causing earthquakes, and all other internal convulsions, by the emission of internal heat, gases, or steam of great elasticity generated by water, percolating the lower strata, or entering by fissures or cavities, and coming in contact with the heat of the incandescent lava, thereby producing great explosions. ☜

It is very likely, that upon more mature investigation, scientific men will abandon the central heat theory, and come to the conclusion, that all internal as well as external, and aeriform changes, and convulsions, are necessarily caused by the great original principle, of interior polarity.

There are numerous cases, in which, certain portions of the earth exhibit evidence of internal heat, but whether such heat is the result of central caloric, in a sensible state, such as incandescent lava, or whether it is the result of ethereal—caloric in a latent state, becoming sensible in the external elements, by the above named law. I claim that the latter is the case.

The discussion of this does not belong to this work, and would not have been alluded to. had it not been by its "supporters" connected with the steam theory.

a collapse, or it may be directed against one head of a boiler blowing it out. This phenomenon of explosions being directed in certain courses, is founded upon the principle of polarity; for example, if the atmosphere of a certain locality, is impregnated with explosive elements, and a steam boiler with water in active ebullition is brought within the sphere of its attraction, two poles, (the one a positive and the other a negative,) will be instantly established, the one at the extreme locality of the explosive element in the atmosphere, and the other will be located in some part of the water of said boiler, for which it has the greatest affinity; both poles must form the line of the axis through the center of the explosive volume.

Each of these poles must have a specific center, which specific center in the boiler, forms the center of the impregnated water, be it much or little; that portion of the water so impregnated with these explosive elements, combines in a spheroidic state, usually covering the flue or flues, with its specific polar center defined—when in this state, if an explosion takes place, it must be preceded by a change of poles, that is, the poles must follow the law of concentration, which destroys the line of mediumship, in which event the principle of polarity is established in the combined elements, which are at this period, within the boiler. The positive pole is that portion of the combined explosive elements in the spheroidic state, where the explosion commences; the negative or opposite pole forms a point opposite; the explosive progress is from positive to negative. Now if the positive pole is immediately over the top of the flues, the negative must be underneath, which is natural, and is usually the case, (from the fact that the furnace which is positive, and the steam room over the top, which is negative,) the two poles between, will naturally be reversed, so if an explosion takes place, it must be directed from positive to negative principles, and therefore would collapse the flues downward. But if a small volume of water near one end of a boiler were in the explosive condition, and the poles in a line with the axis of the boiler, the consequence would be that the head of the boiler would be blown out. But if a large portion of the water in a steam boiler were in an explosive condition, a most violent fracturing of the entire shell would be the result yet the main explosive force would be in the direction of the line of the principle poles. The explosions from these causes, do not act upon the principle of expansion, but upon that of reaction percussion from pole to pole, reacting in all directions; hence the tearing up, and shattering of the wood-work of steam vessels, and the twisting and curling up of

boiler plates like leather.* A regular expansive force, be it ever so great, would not shatter the wood-work of boats, nor would it curl up boiler plates like leather. Such are the results only of those explosive elements in nature, where the particles act and re-act through each other by fulminating percussion. Steam boilers do not explode from excessive steam pressure; steam pressure will only rupture a boiler, if increased beyond the strength of a shell; which would seldom be the case, and would not be productive of any serious consequences. It is the water that explodes in steam boilers with such great violence. A steam boiler may be exploded most violently, though it be filled with water, without leaving any steam space; provided these aeriform elements, before alluded to are present.

If then, steam boiler explosions are caused, (as before stated,) by the explosive combination of certain elements without, with those within a boiler, upon certain polar principles; what will be the natural and successful preventive?

If a man was sinking in fathomless water, by the force of gravity, what would save his life, other than opposite force, which is upon a mechanical polar principle; or if we wish to prevent our bodies from wasting, which is a negative polar condition: we must keep up the proper polar action, by a positive polar condition, which is done by supplying proper nutriment to the digestive functions, and pure air to the respiratory organs; or if we wish to repel darkness, we must produce an excess of light, which is also established upon polar principles; or again, if we wish to conduct the impetuous thunder-clap, harmless down the walls of our buildings, we must establish polar conditions—such as metalic rods, with the lower end deep in the moist earth, or immersed in water, which forms the base or negative pole, while the top end forms the positive. All nature is founded upon these principles—there is no ill in animal sensation, or vegetable life, but what has a remedy, or may be counteracted upon polar principles; while the whole mineral and aeriform kingdoms, in all their various changes act, and re-act, upon this universal original principle of polar conditions. If, then, this is a universal principle, which all

* When the two original poles in the water become dissolved by an explosion, they are instantly fragmented into many poles of a positive and negative nature; these again in the instant of the explosive progress become fragmented into numerous poles of a less terrific character; these again become fragmented into still smaller poles, and so on, extending the volume of the explosion outward from the main original center, until their great number producing such minuteness, as to render the further explosion of poles harmless; yet these polar explosions must continue increasing in numbers, while the sphere of their whole volume is extended to such a great distance in the surrounding atmosphere, until the further polar explosions become mutually neutralized in the atmosphere, in consequence of the loss of caloric in combination with the change of their elementary constitution.

This philosophy is applicable to all explosions, especially those of a "fulminating" nature.

nature is impregnated with both animate, and inanimate, we have a clue to the mystery, and an answer to the question. We must study nature and obey her laws. If we study nature we learn her laws, and if, we obey her laws, we obviate her penalties.

Then as steam boiler explosions are caused by the explosive combination of certain elements, upon polar principles. From well known laws of nature, we may be able to establish polar conditions between the watery elements within the steam boiler, and the aeriform elements without, so as to form a perfect safe-guard. And in order to accomplish this, we must place a copper covering over iron steam boilers, extending down the sides and ends, as far as the fire lines, with a small air space between. This combination of these specific metals with the air space, does, upon the great principles of polarity, answer two important purposes. Copper is positive in this case, while iron is negative. Copper and iron in this peculiar arrangement constitutes a positive pole to the external aeriform column or volume of explosive elements, repeling, and therefore destroying their affinity for the elements within—while at the same time, and for similar reasons, it constitutes a negative pole, to the explosive elements within the boiler, thereby conducting off the excess of caloric, from the explosive elements within, (if there be any,) which may have obtained access through the supply pump, or otherwise. The copper covering which in this case, is positive to the iron, and being in contact with the external elements, forms a positive and repeling pole, while the iron which in this case, is negative to the copper, and in contact with the internal elements, forms a negative, and therefore a conductive or absorbing pole, which destroys the combining polar conditions within the boiler, while the positive pole without, destroys the attractive and concentrative polar conditions of these dangerous elements, which under certain conditions exist outside of the steam boiler.

Having arrived at the foregoing conclusions, by a close observation of nature's laws—which were followed by a series of well directed experiments, I have supported and established the foregoing philosophy, by actual demonstrations.

That water may be exploded in the laboratory under certain conditions, chemists will admit; they will also admit that there exists a chemical affinity between certain materials, which must exist upon the principle of polarity; and why not admit that this principle is a universal law of nature, which it evidently is. It will be further admitted that there are under certain conditions, substances in the atmosphere, (such as the odoriferous principles of plants, the miasmata of marshes and

other matters of contagion, the presence, although sufficiently obvious, to the sense of smell, or by their effects upon the human constitution,) that cannot be detected by chemical tests. Then may it not be, that there exists in the atmosphere other substances, that have heretofore been equally beyond chemical detection? And if such be the case, may it not be consistent with nature, that there are substances in the atmosphere combined with caloric in a latent state, that will upon polar principles, penetrate a steam boiler, and unite with the water under a certain state of ebullition, and form an explosive compound? Scientfic men should ponder, before deciding upon the subject before us! We have said that water may be exploded in the laboratory; it may also be done without entering a laboratory; it is done in numerous instances in the blacksmith shop upon the anvil. It is a usual practice among blacksmiths, to dip the hammer into water, dropping it on the anvil, and holding a red hot iron nearly in contact with it and giving it a blow with the hammer, which instantly developes the latent caloric of the water when detonation, or explosion with a loud report ensues. Water may also be exploded in a common pail by pouring into it certain quantities of fused metal. If, then, water can be exploded under various circumstances, which must be admitted by practicle men, is it irrational to admit that it may be exploded in a steam boiler, if impregnated with a penetrable element combined with latent caloric, which is set free by the contraction of polar conditions? If water is thus exploded, no one can doubt the terrific result a magazine of gun powder would not exceed it. And there is no safety, for the water in a steam boiler under fourteen pounds per inch pressure, may as well explode as that under five hundred pounds. Whenever the engineer finds, (as he thinks,) that the water is too rapidly sinking below the try-cocks, he may be assured that it is assuming a spheroid state, in which case he should instantly warn all those within the reach of danger to retreat, as the event of an explosion is rapidly approaching, unless counteracted by its natural preventive.

In order to ascertain by actual demostration, whether the cause and preventive of steam boiler explosions, (as before stated,) have a foundation in the true science of nature, a series of well directed experiments were made accordingly. These experiments have been repeated from time to time, during a long and tedious series, and have been entirely satisfactory.

Several of these experiments will be given in detail, to show how they harmonize with the true cause and preventive of steam boiler explosions.

The locality selected for these experiments was about one mile South-East of Dayton on the limestone strata, in a ravine about ten feet below the adjacent ground, and on a level with the limestone strata. This locality was selected purposely, as it was thought, if there are any elements in an aeriform state that will penetrate and combine with the water in a steam boiler, that a locality of such description would likely be well adapted for experimenting.

For experimenting, a number of cylindrical boilers were made, 12 inches in length, and 8 inches in diameter—the iron in the shell being made of charcoal manufacture, .02 of inch thick. These boilers were constructed so as to give the joints more strength than usual, this being acomplished by giving them a coat of solder before riveting; and after riveting, a soldering-iron was drawn over the joints to cause a perfect cementing of the joints. Each boiler thus prepared was furnished with a safety valve of a certain area in order to indicate the exact internal steam pressure.

The furnace being constructed of building stones, weighing from 100 to 150 lbs. each, and laid up in a temporary manner, to the height of 18 inches; the outside of it was embanked with earth to prevent the heat from the fuel passing off through the crevices. The frame upon which the boiler rested, was made of bar-iron $\frac{3}{4}$ by $1\frac{1}{2}$ inches, and of such length as to form a frame $7\frac{3}{4}$ by 13 inches—the corners being fastened together by $\frac{1}{2}$ bolts. This iron frame was placed on the stone furnace—the boiler was placed within the iron frame, which was constructed so as to receive nearly half its diameter. The safety-valve adjusting apparatus, was fastened on the top of the boiler; from it extended a thin wire to the distance of 150 feet, where it was attached to a spiral spring scales, for the purpose of accurately weighing the steam pressure. A heavy fencing rail was laid, nearly on a balance across the boiler, to keep it to its place while the wire was drawn to force down the safety-valve, which had a tendency to draw the boiler out of the furnace. All things thus adjusted the copper covering was placed over the boiler, the latter was half filled with water—the fire was then urged until the pressure indicated 250 lbs. per square inch—in which case the heads were forced outward like an air bubble, against the cross bars of the iron frame, rupturing the joints, causing leakages that gradually relieved the boiler of its pressure. The boiler was removed, and repaired, and the second, third, fourth and fifth trials resulted in similar ruptures. This boiler having been repaired in many places, was laid aside and a new one substituted. To prevent the bulging of the heads, (as before stated,)

two pieces of iron $1\frac{1}{2}$ inch square, and $\frac{3}{4}$ inch thick were placed between each head of the boiler, and the cross bars of the iron frame.

The fire was replenished from time to time, until the steam attained a pressure of 250 lbs. per inch, when the furnace was once more filled with fuel; after the lapse of a few minutes the safety-valve indicated 280 lbs. per inch pressure.* At this great pressure, which was 14000 lbs. against each head, no rupture ensued, but, the joints being overcome by excessive pressure, gave vent, which relieved the boiler of 30 lbs. per inch pressure, and when thus reduced to 250 lbs. leakages ceased, and the fire was extinguished, and the steam blown off by the safety-valve. The same boiler, after being half filled with water, was put on the furnace as before—with this difference, however, the (safety cover) was removed. The furnace in this experiment was only once filled with fuel, as it was thought highly dangerous to attempt to replenish it while the copper cover was removed. The safety-valve was adjusted so as to require 250 lbs. per inch pressure, to lift it. The steam pressure gradually increased to 225 lbs. per inch, when it became stationary, in consequence of the fuel being exhausted. After a few minutes, the safety-valve indicated a steam pressure, less than 190 lbs. being an unusually rapid decrease of pressure, which was evidence that a contraction of the elements within the boiler, was in progress—and which I anticipated would result in an explosion. I accordingly prepared to take every observation possible, (being 200 feet from the boiler. In a few moments, a most terrific explosion occurred, which blowed everything into fragments; the stone furnace was broken into pieces and scattered over the ground, some 50 feet around—two stones left whole weighing 90 and 95 lbs were carried six feet from their position—the chimney which was a six inch stove pipe, and three feet in length, was curled up like curled hair, and carried into the air, as high as a tall hickory tree, stood near, and fell over 100 feet from the explosion. The rail that was laid across the boiler, was broken into three pieces, the end pieces were projected on a horizontal line, a distance of 30 feet—the middle piece 4 feet long and weighing 16 lbs. was projected from appearance about 50 feet high, and was found 82 feet from the explosion—the ground was covered with fragments of stone, iron, boards and wood, (which were used about the furnace,) for 200 feet around—the boiler, which was rent by angular fractures, and flattened out, was carried some 20 feet—the sides of the iron furnace frame, which were of iron, $\frac{1}{8}$ inch thick

*280 lbs. pressure in the above boiler, would be equal to 700 lbs. per square inch in a boiler 40 inches in diameter; and is 56000 lbs. per inch section, and is as much as the best of iron will bear.

and 6 inches wide, were rent and curled up like leather, and carried 30 feet—one head of the boiler, was found 73 feet and the other 75 feet from the explosion—the front furnace bar $\frac{3}{4}$ by $1\frac{1}{2}$ inches and 10 inches long, weighing 4 lbs., was torn from the bolts, and projected 156 feet.

This explosion was one of extraordinary character, and proves several important points, beyond all controversy.

1st. The exploded volume, which was at the instant of the explosion distinctly seen, to be that of a sphere; its dimensions being calculated from the range of certain conspicuous objects, placed at each side of the furnace for that purpose—and after making all reasonable allowances, it was ascertained that the exploded volume was at least 15 feet in diameter, making 10366 volumes, that of the steam space in the boiler, which is 300 cubic inches. If such had been simple steam at 190 lbs. per inch, (which the scales indicated,) and instantly relieved from its confinement, it would have expanded to a sphere of only 21 inches in diameter—and to 16 volumes its former confined state. But instead of the latter law of simple steam expansion, from 1 to 16 volumes. we see that the explosion, was from 1 to 10366 volumes—a great difference indeed, but, not more than is necassary to produce such a violent explosion.

2nd. The water did explode—this is evident, from the fact that no appearance of any was discovered immediately after the explosion, either on the ground, or projected pieces of boards, wood, and rails, that lay near, at the time of the explosion. Another evidence that the water exploded, is that the heads of the boiler were driven outward, below the water level, with great violence, at the instant of the explosion. The heads bear positive evidence, (sufficient to convince any rational man,*) from certain breaks which they received in the act of projection out of the iron furnace frame, that the explosion was developed in the boiler below the water level.

3d. The explosion was forward, from the fact that the boiler shell, boiler heads, iron furnace frame, most of the stone furnace, safety-valve apparatus, and every thing around the furnace and connected with the boiler was projected forward, with the exception of the chimney. A regular expansive force, such as the elasticity of steam, or atmosphere, does act equally in all directions, it will not project the aft head of a boiler forward,.

If such were the character of steam, it could not be relied on as a motive power, for it might with the same propriety act only in one direction, in a working cylinder; and that direction, might per chance

* These fractures are preserved, and may be seen with the marks referred to.

be in the direction of the cylinder head, without making any impression upon the piston head.*

4th. It will be remembered that this boiler was set into a strong iron frame, with a piece of iron $1\frac{1}{2}$ inches square, and $\frac{3}{4}$ thick placed tight between the cross bars of the iron frame and the center of the boiler heads, in order to keep the boiler heads from bulging, with the high pressure; in the explosion, the percussion was so great on the heads, as to force the lower part of the iron blocks through the boiler heads, causing a square break of 1 inch in the aft head, and one of $2\frac{1}{2}$ inches in the front head—the metal in the heads was .09 of an inch thick. Now how much power was necessary to force those iron blocks through the heads as above stated? This can be answered on the principle of punching—it requires about 12000 lbs. pressure on a $\frac{3}{4}$ inch punch, to punch iron sheets the thickness, of those heads—and a $2\frac{1}{2}$ inch break is equal to more than a $\frac{3}{4}$ inch punch. At the instant before the explosion, the internal steam pressure against the heads, was but 9500 lbs., lacking, 2500 lbs. of the requisite pressure, to force those blocks through the heads, even if the pressure exerted against the entire surface of the head, were brought to bear upon that point, which was not the case, however,—from a close examination of the break, in connection with experiments causing similar breaks, it is evident that in the above case, the whole pressure of at least 12000 lbs., must necessarily have been brought closely along the edge of the break, not extending to an area of more than $\frac{1}{2}$ a square inch. For example, if a plate of iron 8 inches in diameter and .09 of an inch thick be laid upon a block of iron $1\frac{1}{2}$ inch square, and an atmospheric or hydrostatic pressure is brought to bear upon its surface, for the purpose of pressing a hole through it, none of such pressure will be of any service, only that which is directly over the sides of the iron block, the balance will only have a tendency to bend the plate.

Again if it were simple steam pressure, that caused those square breaks in the boiler heads, why not cause them when two hours before with the same boiler, the steam pressure was 280 lbs. per inch, equal to 14000 lbs. against the heads—this whole pressure against the heads, was resting against those square blocks of iron. Again why did it not explode at 280 lbs.,† Every circumstance connected with this explosion proves clearly, that a combination of explosive elements occurred.

* A solution of this is found in the treatment of polar principles.

† Such is often the case, that boilers explode most violently, while the steam gage indicates less pressure than the boilers bore on former occasions; this proves that they explode by a cause aside from steam pressure.

And in no case, of many experiments, did an explosion occur when the safety cover was attached, though in all cases, the pressure was finally increased until the boilers ruptured at the weakest point, which relieved them of excessive pressure, without doing any further damage.

It has also been ascertained by experiments, that the copper cover was the cause of generating and retaining, with the same amount of fuel, a more uniform working steam pressure. In two experiments, however, it was ascertained, (remarkable as it may appear,) that the pressure was raised in six minutes, from 40 to 250 lbs.; at this period of the experiment, the boiler apparently became enveloped with an aeriform substance, of a blue appearance, and the steam was in a few moments lost. A second fire was raised, and a similar result followed —and a third also, after this, there was an attempt made to replenish the fire again, when it was ascertained that the copper cover was excessively hot—and upon further examination, it was ascertained that there was no water in the boiler, although it was half full, one half hour previous—yet no steam was blown off by the safety-valve, nor were there any perceptible leakages. At this period the copper cover was examined, and proved to be intensely heated, and of such a singular nature, that drops of water that were thrown upon it, were repelled in such a manner, as proved clearly the extraordinary polar power in this case. And the copper cover, with the iron boiler, after being removed from the furnace, retained this degree of heat, and repelling power to such a great length of time, as was truly remarkable.*

In many experiments that were afterwards made one only, presented the above characteristic in every particular, with the exception that a portion of the water remained in the boiler.

Many experiments of various characters were made, but it is deemed unnecessary to refer to them, as they harmonize with those already alluded to.

In conclusion, I would state, that after much research, in connec-

*If such a state of things would occur on a steamer, the consequence would be, that the engines would instantly cease action. There is no doubt, but that there were two violent explosions obviated in those two cases by the copper covering. The water in these cases may have been impregnated with explosive elements, before it was put into the boilers, and when combining in a certain state of ebullition to form an explosive compound, while the caloric necessary for the perfect union thereof, was conducted off by the polar condition of the copper and iron. The query may be, what become of the water in those two cases, did it penetrate the iron? The answer is, it did not penetrate the iron in its fluid, or even gasouse state, but it may by polar conditions have been converted into its original ethereal-caloric state, in which state it would not only penetrate, or permeate iron, but all other substances that man is acquainted with. That the elements that man is acquainted with, in the solid, liquid, gaseous, or aeriform state, have been developed from ethereal-caloric, may involve an argument which is reserved for a future work of a different character

tion with much experimenting of various kinds, the conclusion naturally arrived at, is, that all formations, and combinations of matter, contain the indelible qualities, of their original nature, which is ethereal* caloric. All subsequent combinations of matter in the aeriform, gaseous, liquid, and solid state, are only developments of the above named original nature, upon the principle of natural polarity. And this original ethereal caloric, in a latent state, pervades all subsequent material nature. And under a similar condition of natural polarity, matter either in the solid, liquid, gaseous, or aeriform state, may be decomposed, so as to assume the ethereal caloric state again. Ethereal caloric, in a latent state, constitutes the aeriform or external elements, (spoken of) which often surround and permeates a steam boiler, thereby forming a union with the water—and upon more perfect polar conditions, the water or a portion thereof, is instantly decomposed into the gaseous, and thence into the ethereal caloric state.

If the water in a steam boiler were instantly converted into the perfect ethereal-caloric state, then boilers would not explode, because this substance will permeate iron, like light does transparent objects. But the explosion occurs while the water passes from the liquid, to the gaseous, and from the gaseous, to the ethereal-caloric state. Sometimes the explosion may occur, (if there is much water in the explosive condition,) between the liquid and gaseous state, and at other times, if there is but little water in the explosive condition, and the boiler strong—the explosive progress within the boiler, may be carried beyond the gaseous state, before the shell will yield.

By a careful perusal of the foregoing pages, it will be seen that I attribute all steam boiler explosions to one cause, which may be termed Ethereal-caloric.

Ether prevades all material nature, and all unoccupied space ; its character is of the highest mobilty. Caloric in a latent state, prevades all material nature only—some portions of material nature posses a higher degree of latent caloric, than other portions ; while ether is distributed uniformly throughout all material nature, as well as unoccupied space. Ether being uniformly established throughout all nature, is endowed with the original or positive characteristic. While latent caloric pervades material nature only, and that in various degrees, which gives it a negative characteristic to ether.

Latent caloric exists in the atmosphere, more abundant in some

* The term ethereal should not be confounded with the fluid known in chemistry, by the name of ether.

localities,* than in others, therefore combining with ether, which constitutes ethereal-caloric. And thus ethereal-caloric, becomes a positive pole in the atmosphere. And as a positive pole, cannot exist in nature, without a radiation of its peculiar condition upon some object, or substance of an impressible, or absorbing nature, which constitutes a negative, or absorbing pole, therefore this aeriform ethereal-caloric must seek an oposite pole, which is often the water in a steam boiler.

The combining of the water, and the above named elements, up onthe principle of natural polarity, causing the development of latent heat of such intensity, and peculiarity, as to decompose the water, or a portion thereof instantly into the gaseous, and thence into the ethereal-caloric state.

HEATING APPARATUS.

Of the many artificial evils that have been introduced among civilized nations, the artificial mode of heating dwellings, is probably one of the most destructive to human life. The ordinary iron heat diffusing devices now in use, (such as stoves, furnaces, &c.,) are one of those great evils that has been gradually introduced by civilization. From the almost universal practice of heating apartments with the ordinary iron stoves, all classes and conditions of the human family are subjected to its pernicious influences. Not only are the olfactory nerves affected by the vitiated atmosphere radiated from iron heated surfaces, but the pulmonary organs become so deranged that they will not fully perform their natural functions, which often lays the foundation of that frightful catalogue of pulmonary diseases, that prevails to such an enormous extent among those nations that live in artificially heated apartments. The economy of the animal kingdom is so arranged, that each individual organ is intended by nature to harmonize with the whole combination of organs, (belonging to an individual being,) without causing any derangement or disease until the entire complicated machinery is with old age worn out.

According to the best chemical analysis, atmospheric air contains by weight 23.10, *by volume* 20.90 *per cent. of oxygen, and by weight* 76.90 *by volume* 79.10 *per cent. of nitrogen, with traces of carbonic acid gas, and a variable quantity of watery vapor.*

Atmospheric air inhaled by the lungs, compared with that which is exhaled from the lungs will show that it underwent a change; the tempertaure

* Those localities where the inflamable gasses exist to a greater extent.

is raised to that of the body, or about 99° Fahr., while the oxygen is diminished about 4.40 per cent. by the process of respiration; and the exhaled air contains a corresponding portion of carbonic acid. This shows that the oxygen in the process of respiration has changed so as to yield, if chemically tested, about 4.40 per cent. of carbonic acid. The oxygen inhaled by the lungs unites with the carbonaceous matter of the dark blood, and forms carbonic acid, which is expired, leaving the blood of a bright red color. This process of cleansing the blood with oxygen takes place once at every breath or inspiration. If this re-invigorating process within our lungs should be suspended, we would live but a short period.

From chemical tests it does not appear that nitrogen undergoes much of a change by respiration. The absorbtion of nitrogen into the body by the lungs, is a subject upon which chemists disagree.

The foregoing in italics is a view of the subject based upon certain chemical experiments, and should only be received as true, so far as the experiments are applicable to the subject under consideration.

Let us now take a natural view of this important subject. The organization and combination of the human constitution is a developement of nature subsequent to that of atmospheric air. The pre-existence of atmospheric air, is evidence that it was not compounded to be adapted to the human constitution; but the human constitution in its formation by natural laws is adapted to the respiration of natural atmospheric air. From this natural view of the subject, it may be clearly seen, that if we disturb the air in its natural combination, by artificial apparatus, (such as the ordinary iron stoves, &c.,) we vitiate it, or in other words, it is rendered unfit to support respiration. And we need not apply chemical apparatuses to ascertain whether the a tmosphere is rendered noccuous, or unfit for respiration; the human constitution is the best aerometer, especially if it has been for a long time living in obedience to natures laws, in which case it becomes almost perfect in detecting the state of the atmosphere. An individual who has been, (as before stated,) living in obedience to natures laws, especially if he has been breathing pure natural air for some time, can discover a great difference in the air the moment he enters an apartment that is artificially heated with the ordinary iron stoves, furnaces, &c., now in use. It produces a similar effect upon his constitution as the atmosphere in a crowded assembly does, or that of an ill-ventilated room. All persons do more or less feel sensible of the unhealthy state of the atmosphere in stove rooms, and other ill-ventilated apartments, it produces a coma —that is distructive to health, and finally lays the foundation for many diseases in after life. Those who are for a long time subjected to such

unhealthy atmosphere, become so accustomed to it that they finally become insensible to the noxiousness thereof—while at the same time the effect upon the constitution is like that of a virulent canker. I have often been surprised upon entering assemblys in ill-constructed halls, stove rooms, private and public offices, and even filthy cities, (all of these places contain an artificial vitiated state of the atmosphere,) where men, women and children are subjected to this growing canker, where they can remain for hours, and inhale into their systems that which to them is poison. Human beings ought not to allow their lungs to be inflated for even one minute with such a great distroyer of human life. Although it may seem out of place here, yet before closing this paragraph, I consider myself under moral obligation to present to the reader at least an abstract hint of the artificial evils that have silently been introduced into what men call civilization: such as a densely populated city which is a great source of accumulating filth, thereby causing the atmosphere for miles around unfit for healthy respiration—and the annual consumption of immense quantities of unnatural stimulating meats and drinks; besides many other intemperate habits—and many thousand tons of that most noxious weed "tobacco" which is annually used—and rivers of intoxicating liquors that are drank instead of that pure water that nature has provided for all animated beings. The foregoing are the heads of many branches of destructive evils, that fill your cemeterys with many millions of human beings of a premature age—while the hereditary influence thereof, aims the immutable penalty at the existence of the human race! Reliable statistics show that some of those nations which stand first in what is termed civilization,* have had their generations reduced in a short period from seventy years duration down to twenty-five years! This is a gloomy picture; but it is only an abstract of the reality. Those advanced nations will be scourged with diseases, and consequently with a diminution of generations, until they learn nature's laws and practice obedience thereto. And there is no other power to save us from disease and degeneracy than that of learning and obeying nature's laws.

The heads of evils as stated in the foregoing paragraph, are but the legitimate offspring of one parent cause (the chief monarch) of human disease, debility, degeneracy and death. And this one parent cause is a vitiated state of the atmosphere—a state that does not support healthy respiration. The animal economy in its various phenomena, connected with all surrounding circumstances and conditions,

*The United States of America.

shows clearly that the healthy condition and development of the entire complicated organization of the human constitution, depends upon the respiration of perfectly pure, natural and congenial atmospheric air. Let the kind parent bestow ever so much care upon the beloved offspring, though it be proper clothing, natural food and drink, perfect cleanliness, proper exercise and proper rest, and everything else of a temporary nature; yet if the great natural law of healthy and congenial respiration is violated, that is, if the parent permits the child's residing in a place or locality where the atmosphere is in a vitiated state, either from artificial causes or otherwise, the child, while in this latter condition, will not develop that great intellect, nor will it obtain that healthy physical constitution, or gain that longevity, which would have been the consequence, if this most essential law of respiration had not been infringed. Even an individual, for example, who has fortunately been placed in the most favorable circumstances, and has thereby obtained a bright moral and intellectual nature, and a well proportioned and healthy physical constitution, may become morally and intellectually degraded, and physically debilitated by being subsequently continually subjected to the breathing of vitiated atmospheric air. A vitiated state of the air that we breath, or an unhealthy respiration, is more detrimental to the moral, intellectual and physical constitution than all other causes combined, by which we are surrounded—it blunts the higher nature of the mind, producing a kind of coma, in which state the inferior animal and selfish qualities of the mind assume the government of the whole organization—stimulating it to selfish desires that leads to licentiousness, debauchery and degredation—this is abundantly manifest throughout the civilized world—and for the evidence the reader need only be refered to those places, and localities where the air is most foul, or vitiated—there can be seen a gloomy verification of the foregoing.

A healthy respiration is the main-spring of our vital actions—it reinvigorates the healthy and higher nature of all animated beings at every inspiration. To ascertain the influence of respiration upon the animal economy, we nead only try the experiment. If respiration is voluntarialy suspended, although the other absorbents of the body be left undisturbed, death will close the experiment in a few moments;* while if the other absorbents are suspended, and the healthy respira-

* The well known circumstances that occurred in the Black Hole in Calcutta, is evidence of the importance of pure air. "In this dungeon, eighteen feet square, and having only two windows on the same side to admit air, one hundred and forty-six men were immured. In six hours ninety-six of them died from suffocation; and in the morning, when the doors were opened, only twenty three out of the whole number remained alive."

tion left undisturbed, life will comparatively be retained a great length of time. This shows that all the functions of the animal economy are dependent upon a healthy respiration as a prime mover of the complicated machinery. Then if our happiness as a consequence of the healthy state of our physical in connection with the intellectual and moral constitution, depends upon a natural and healthy respiration, how important is it for mankind to endeavor to obtain pure air, and preserve at all times a perfectly congenial and healthy respiration. Besides public artificial means of manufacturing vitiated atmosphere, (as before stated,) civilization has adopted a private mode of destroying the vital qualities of the air—this is done in offices, work-shops, parlors, kitchens and even sleeping rooms, by the ordinary heat diffusing apparatuses. This artificial practice of vitiating the atmosphere in our dwellings with stoves, furnaces, &c., has become such a manifest evil, that practical physiologists, and reformers have again and again protested against such practices.

But what will we do, these heat diffusing inventions are safe, convenient and economical as far as fuel is concerned, is the universal response. Is there any mode by which we can continue the use of our favorite stoves, and other heat diffusing devices without impairing the purity of the atmosphere in our apartments? The answer is, nature in her vast repository has a preventive in this case, as well as she has a sovereign balm for every ill, if properly understood. In order to apply the preventive, we must first learn the cause. Atmospheric air is composed of several gases, and vapor, these contain within their atomic constitutions, ether combined with latent caloric—these are the only two original elements combined that support combustion and respiration. Those two elements are the same that were alluded to under the head of Steam Boiler Explosions, and are governable by a similar apparatus. An ordinary stove or heat-diffusing device, with fire in it, constitutes a negative or absorbing pole—abstracting these two life invigorating elements from the atmosphere, and depositing them around the heated surface---which they uniformly permeate and uniting with the gases of the combustibles in their ascent through the smoke-pipe, leave the air around the stove or other heated surface, destructive to the human constitution.

All that we have to do, then, is to reverse this state of things, which may be accomplished by forming an opposite or repelling pole around the stove or other heat-diffusing surface.

To constitute a repelling pole it is necessary, (as in steam boilers,) to form a covering or casing of sheet copper around the heated surface.

This prevents the ethereal-caloric from being abstracted from the atmosphere in our apartments---it radiates the heat more uniformly throughout a room---besides saving a large per-centage of fuel.

The reason why the atmosphere in apartments heated with the ordinary fire-place, or open grate is more healthy and congenial to the human constitution, than that in rooms heated with the ordinary stoves, furnaces, &c., is obvious, from the nature and construction of these heat-diffusing apparatuses. In the case of the open grate, and fire-place, the smoke passage in the chimneys is usually constructed proportionate to the hearth opening, or heat radiating surface, so that the whole current of atmosphere composed (as before stated,) of several gases, vapor, and ethereal-caloric, that passes from the room into the fire, is carried upward through the smoke-passage. This constant draft of atmospheric air from a room into the fire-place, thence up the smoke-passage, inclines to produce a vacuum in the room which is alternately supplied from without through the crevices of the windows, doors, key-holes, and other inlets ; thereby supplying natural air to the inmates, for healthy respiration.

With regard to stoves, furnaces and all other metalic, or even non-metalic heat diffusing surfaces, the case is different. These heat diffusing surfaces are so constructed, that the atmospheric current passing from the room through their construction, is very small in proportion to the heated surface exposed to the atmosphere in the room. This reveals the whole mystery of unhealthy stove rooms. Instead of an atmosphere exhausted of its ethereal-caloric in a room uniformly passing up the chimney, (as is the case of the fire-place, or open grate) it only is deposited against the heated surface, with the exception of a small current that passes by the draft of the stove, or other heating apparatus, off by the smoke-pipe. The ethereal-coloric combined with the atmosphere, is upon polar principles deposited around the heated surface, penetrating it and passing off through the smoke-pipe, while the gases that constitute the atmosphere do not penetrate metalic surfaces, and are therefore left in the room. This process of sifting the life-invigorating principle (ethereal-caloric) out of the atmosphere in a room through the heated metalic surfaces of stoves &c., is continually going on while those surfaces are in a heated state ; thereby leaving such rooms filled with the gasses that constitute the negative state of the atmosphere, (named oxygen, nitrogen and carbonic acid,) neither of these gasses uncombined with the positive nature (ethereal-caloric) can support combustion, or respiration. Respiration is only combustion in a more complicated, or rather im-

perceptible state—for example, fuel, such as wood, coal and other combustibles, are negative substances, and in an uncombined state, would not contain the cause of self-consumption, or self combustion—but combined with the positive nature, (ethereal-caloric,) which is the true cause of combustion, fuel is rapidly consumed. So with the animal constitution, it is so arranged that all the absorbents are inlets for these most essential elements as well as the cutaneous system or skin—food and drink that is taken into the system contains these positive elements. Absorbtion, exhalation, digestion, secretion and excretion, are only combustion in a higher state of combination—while the process of combustion is more obviously manifested in the process of respiration. If a human being were confined in a close room without the possible inlet of air from without, death would be the result in a short time, in consequence of the exhausted state of the atmosphere; that is the ethereal-caloric existing in the atomic constitution of the atmosphere, is abstracted by the process of inhalation, and consumed or converted into a life-invigorator in the lungs in the process of respiration or combustion at every inspiration until the whole is abstracted leaving the room filled with simple atmospheric gases.

Such is precisely the case with the ordinary metalic heat diffusing devices now in use; the stove, or other heated surface, (like the lungs,) abstracts the ethereal-caloric, and sifting it through the heated surface, leaving the atmospheric gases in a simple or unnatural state. If the room for the experiment were constructed perfectly air-tight, with a metalic stove in operation, and a man confined in the room, he would live but a short time, in consequence of the heated surface abstracting from the surrounding atmosphere the vital principle, (ethereal-caloric,) thereby depriving the lungs of those two elements which are the prime cause of combustion and respiration—in the absence of which, the animated state of the physical body must cease.

Thus it is evident, in order to continue life at all in a stove room, that air must be admitted from without, in addition to that which the lungs destroy, to supply that which the heated surface of the stove vitiates. For example, if 6 lbs. of fuel, in a stove of 10 square feet exposed surface, will vitiate 2400 cubic feet of atmosphere in an air-tight room in raising the temperature in 20 minutes from 64° to 100° Fahr., then it is evident in order to restore the atmosphere in the room, these 2400 cubic feet of vitiated air must first be expelled, or drawn off by ventilation, and its volume supplied by pure atmosphere from without, which would require an additional 6 lbs. of fuel to heat it from 64° to 100° Fahr., and this fresh supply of air will, as before stated, be

vitiated in consequence of the heated surface, so that a continual and copious ventilation on account of the heated surface will be necessary in order to obtain atmosphere in a stove or furnace room that will support respiration—which at best only supports the human constitution in a debilitated state—besides requiring double the amount of fuel to keep the apartment heated to a comfortable degree of temperature. It is evident from the foregoing that if we can by any device preserve perfectly pure, and healthy, atmosphere in stove or furnace heated apartments without extra ventilation, or in other words, outlets of the heated air from those apartments, other than that which passes through the stove, or furnace by simple draft, that we economise nearly fifty per cent. in fuel. In this case it would only be necessary to admit air from without to supply that which becomes vitiated from the exhalation of the lungs—and it being comparatively little to that rendered noxious by 10, 20, or 30 square feet, (as the case may be,) of iron heated surface.

The foregoing has been established by practical demonstrations. This improvement can be used in sleeping rooms, private and public apartments, hospitals or asylums, and all other institutions with perfect impunity. It is founded upon natures laws, and therefore can be relied on. If generally adopted in practice, it would save thousands, and probably millions, from a premature grave, throughout this country alone.

PATENT.

Application was made by the Author, January 11th, 1855, at the United States Patent Office, for Letters Patent, for the invention relating to Steam Boilers, and all Iron Heat Diffusing Devices, (as before described,) for which Letters Patent were issued July 3d, 1855. It may be proper to state that the foregoing pages, (although in the Preface dedicated to the investigation of practical men,) were partly written in answer to certain scientific interrogatories, put to the inventor by the office, during the examination of the application. Some of the proof-sheets were forwarded to the Commissioner of Patents, prior to the final determination of the case.